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AN ECOLOGICAL INVESTIGATION OF REVETTED AND NATURAL BANK HABITATS IN THE LOWER MISSISSIPPI RIVER

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REPORT 9
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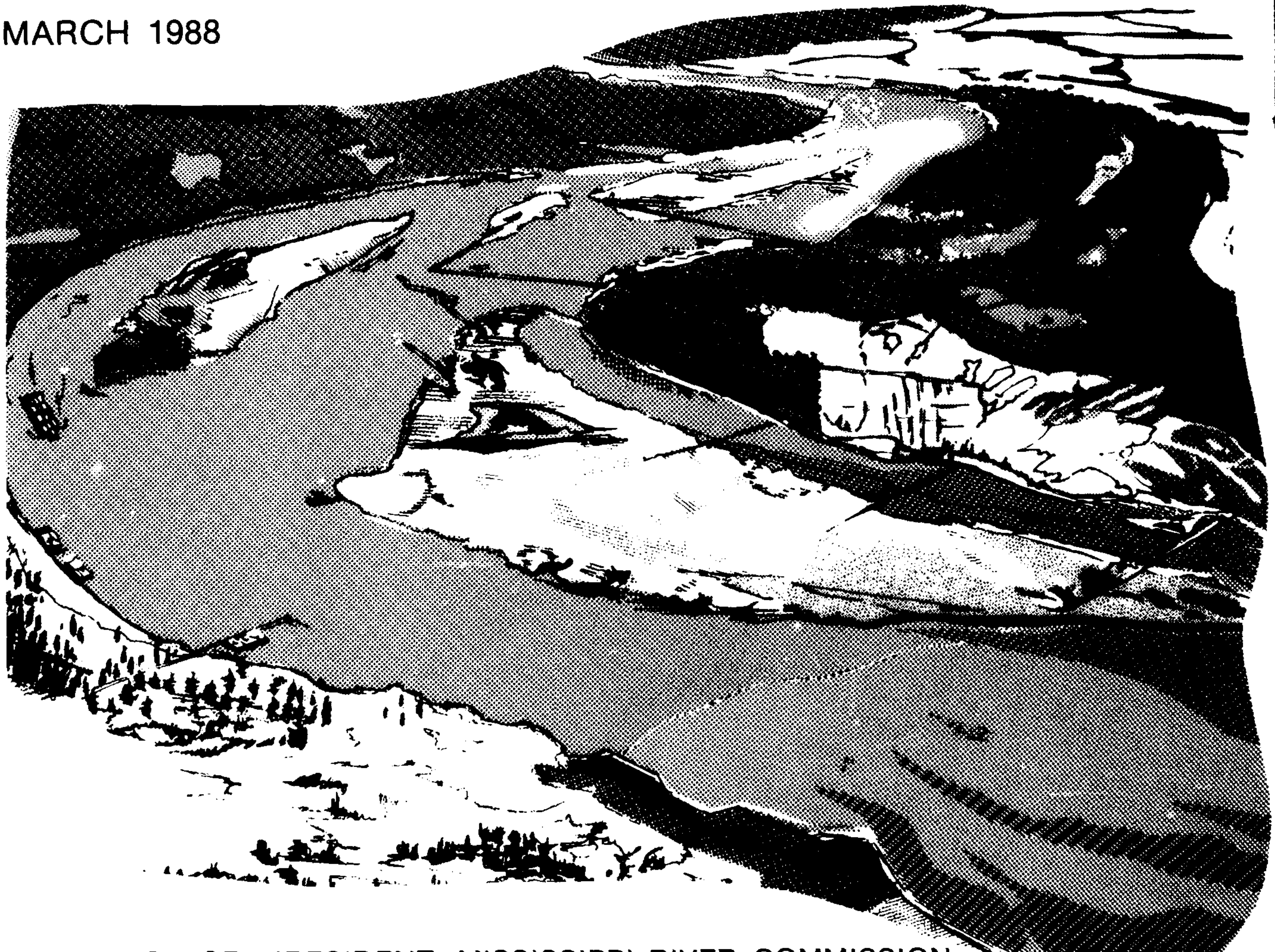

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An Ecological Investigation of Revetted and Natural Bank Habitats In the Lower Mississippi River

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Chemical, physical and biological attributes of the aquatic habitats associated with four revetments and two natural banks in the Lower Mississippi River were surveyed during summer and fall 1985. The revetments were located at approximately river miles 446, 370, 309, and 41; the two natural banks were located at river miles 368 and 41.

With the exception of water temperature in the fall, temperature, dissolved oxygen, pH, conductivity, turbidity, oxidation-reduction potential, total organic carbon, and dissolved and suspended solids showed relatively little variation over the entire study reach.

Natural bank substrates were characterized by consolidated clays, with sand and silt, or sand and gravel, occurring frequently. Revetted banks were characterized by articulated concrete mattress (ACM), about one-half of which appeared to be overlayed with

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sand and silt. Submerged snags were common along the two natural banks but were rare along the revetments.

Macroinvertebrate community composition depended primarily upon the substrate type and current speed encountered at both revetted and natural banks. Consolidated clay substrate, found only on natural banks, were colonized primarily by the burrowing mayflies Pentagenia vittigera and Tortopus incertus. Sand-silt substrates in areas of slow currents were dominated by tubificid oligochaetes; areas of sand substrates and moderate to fast currents were characterized by the chironomids Robackia claviger and Chernovskiia orbicus. Clean ACM in moderate to fast currents provided habitat for hydropsychid caddisflies, primarily Hydropsyche orris, sprawling mayflies, Stenonema sp., and chironomids such as Rheotanytarsus sp. Macroinvertebrate communities colonizing snags were similar to those found on clean ACM.

ACM surface modification experiments showed that mean densities, biomasses, and number of taxa of macroinvertebrates were greater on grooved blocks than on other modification type, or on control blocks.

Both traditional fish collecting gears and hydroacoustics indicated differences in fish density between the two natural banks, among the three revetted banks, between the natural and revetted banks at sites at which both occurred, and between seasons. Hydroacoustics demonstrated a considerable difference in fish lateral and vertical distribution among all five banks; estimates of fish sizes also varied greatly. Fish communities at the upstream two sites were characterized by catfishes, freshwater drum, gizzard and threadfin shad, common carp, minnows and shiners, and white bass. Community composition at the downstream-most site consisted primarily of bay anchovy, striped mullet, freshwater drum, catfishes, and Atlantic stingray.

PREFACE

The Lower Mississippi River Environmental Program (LMREP) is being conducted by the Mississippi River Commission (MRC), US Army Corps of Engineers. It is a comprehensive program of environmental studies of the leveed floodplain of the lower Mississippi River and the main stem Mississippi River and Tributaries Project (MR&T). Results will provide the basis for recommending environmental design considerations for the navigation and flood control features of the MR&T Project.

One component of the LMREP is the Revetment Investigation. This report contains results of a study documenting the physicochemical environments and the distribution and relative abundance of fishes and invertebrates associated with three revetments and two natural banks in the Lower Mississippi River. Data were collected between river miles 41 and 446 AHP during summer and fall 1985.

Biological and physical data were collected by individuals from the US Army Engineer Waterways Experiment Station (WES). This report was prepared by Messrs. John A. Baker, Richard L. Kasul, C. Rex Bingham, and Richard E. Coleman, Dr. C. H. Pennington, and Ms. Linda E. Winfield, WES.

The investigation was managed by the Planning Division of the MRC and was sponsored by the Engineering Division, MRC. Mr. Stephen P. Cobb (MRC) was the program manager for the LMREP. The investigation was conducted under the direction of the President of the Mississippi River Commission, BG Thomas A. Sands, CE.

CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
acres	4046.873	square metres
feet	0.3048	metres
feet per second	0.3048	metres per second
miles (US statute)	1.609347	kilometres

AN ECOLOGICAL INVESTIGATION OF REVETTED AND NATURAL BANK HABITATS IN THE LOWER MISSISSIPPI RIVER

PART I: INTRODUCTION

Mississippi River and Tributaries Project (MR&T)

1. Along the course of the Lower Mississippi River and on the associated floodplain, flooding has historically been a major deterrent to development. For example, destructive floods occurred in 1849, 1858, 1882, 1897, 1912, 1913, 1916, 1922, 1927, 1937, and 1973. The Mississippi River Commission (MRC) was established by Congress in 1879 to develop and carry out flood control and navigation measures for the Lower Mississippi River that would be financed by the Federal Government.

2. The devastating flood of 1927, the flood of record, destroyed many existing levees, flooded large areas of farmland and numerous municipalities, and caused loss of livestock and human life in the Lower Mississippi Valley. This flood motivated the Congress to pass the Flood Control Act of 1928, which authorized the Mississippi River and Tributaries (MR&T) Project. The MR&T Project is a comprehensive plan for flood control and navigation works on the main stem Lower Mississippi River and tributary streams and consists primarily of levee systems, channel improvement works, and floodways. The MRC is responsible for carrying out the project.

Lower Mississippi River Environmental Program (LMREP)

3. The Lower Mississippi River Environmental Program (LMREP) is being conducted by the MRC. This program has as objectives the development of baseline environmental resources data on the river and associated leveed floodplain and the formulation of environmental design considerations for channel training works (dikes and revetments) and the main stem levee system. The LMREP was initiated in fiscal year 1981 and is scheduled for completion in fiscal year 1988. Fishery and wildlife populations and habitat are the main focus of the LMREP. The LMREP is made up of five work units: (a) levee borrow pit investigations, (b) dike system investigations, (c) revetment investigations, (d) habitat inventories, and (e) development of the Computerized

Environmental Resources Data System (CERDS), a geographic information system containing environmental data. This investigation is part of the revetment investigations work unit.

4. Revetted banks constitute about three to five percent of the total surface acreage of aquatic habitat in the Lower Mississippi River, depending upon river stage. Natural banks, excluding sandbars, constitute approximately one percent (Cobb and Clark 1981). These low percentages do not accurately reflect their relative importance to the overall river ecosystem, however. At moderate to low flows, from 29 to 45 percent of the available aquatic habitat consists of main channel, an area of strong currents and coarse, shifting substrate generally thought to support few aquatic organisms.

5. Under the Mississippi River and Tributaries (MR&T) Project, the US Army Corps of Engineers (CE) authorized the construction of 968.16 miles* of revetment on the Lower Mississippi River. As of 1 January 1986, 865.20 linear miles of revetment have been placed and an additional 102.66 miles of revetment are planned for construction before the channel improvement portion of the MR&T Project completion date of March 2010. Approximately 2 percent of the total revetment will be repaired annually.**

6. When the currently authorized work is completed, nearly 50 percent of the bankline of the Lower Mississippi River will have been revetted (Pennington, Baker, and Potter 1983). This constitutes a considerable ecological change in the aquatic ecosystems of the river, and work has been ongoing as part of other CE investigations to assess the effects of this change (Pennington et al. 1980; Mathis et al. 1981; Bingham, Cobb, and Magoun 1980; Conner, Pennington, and Bosley 1983; Pennington, Baker, and Bond 1983; Pennington, Baker and Potter 1983; Beckett et al. 1983). This study, as part of LMREP, was conducted in 1985, and concentrated entirely on revetments and natural banks. The objectives were:

a. Obtain comparative measurements of physical and chemical characteristics of three revetments and two natural banks.

b. Compare the distributions and abundances of fishes and benthic macroinvertebrates of three revetments and two natural banks.

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* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 3.

** Personal Communication, July 1986, US Army Engineer Division, Lower Mississippi Valley, Vicksburg, Miss.

c. Evaluate the effects of several modifications to the surface of articulated concrete mattress (ACM) on benthic macroinvertebrates.

PART II: STUDY AREA

7. The Mississippi River is the fourth largest drainage basin in the world (1,245,000 sq. mi), exceeded in size only by watersheds of the Amazon, Congo, and Nile Rivers. The river drains 41 percent of the contiguous 48 United States and a portion of Canada.

8. The Lower Mississippi River flows from the confluence of the Ohio and Middle Mississippi Rivers at Cairo, Illinois, to the Gulf of Mexico, a distance of approximately 975 river miles (RM). At Vicksburg, Mississippi (RM 437), approximately midway along the Lower Mississippi River, the mean annual discharge of the river is 552,000 cubic feet per second (cfs); the mean monthly maximum and minimum flows are 948,000 cfs in April and 261,000 cfs in September, respectively. The maximum flow recorded at the Vicksburg gage was 1,806,000 cfs during the flood of 1927; the discharge during this flood has been estimated to have been 2,278,000 cfs if the mainline levees upstream of Vicksburg had not crevassed (Tuttle and Pinner 1982). The difference in river stage between the average minimum discharge and average maximum discharge is about 27 feet on the Vicksburg, gage although river stage may fluctuate more than 45 feet in stage in a particular year. Suspended sediment transported by the river averages 161 million tons per year (Keown, Dardeau and Causey 1981).

9. Flooding along the river may occur during the fall, winter, and spring and varies considerably in time, stage, and duration from year to year. Highest stages are typically reached from March through May. On the average, peak flows occur in April.

10. The approximately 2.5 million acres of leveed floodplain are composed of 81 percent land and 19 percent water, including abandoned channels, oxbow lakes, levee borrow pits, and the main river channel (Ryckman et al. 1975). The floodplain of the Lower Mississippi River is leveed along both banks. The main stem levees are continuous on the west bank except at the confluences of the St. Francis River and the Arkansas-White Rivers. Levee segments and bluffs alternate on the east bank. A system of dikes and revetments is being constructed throughout the river for navigation and flood control purposes.

11. The study reach extended from just north of Vicksburg, (RM 460) downstream to Port Sulphur, Louisiana (RM 40). Four general sampling areas were selected within this reach (Figure 1). The Marshall-Brown's Point Revetment (RM 444.5-448), just upstream of Vicksburg, was the northernmost

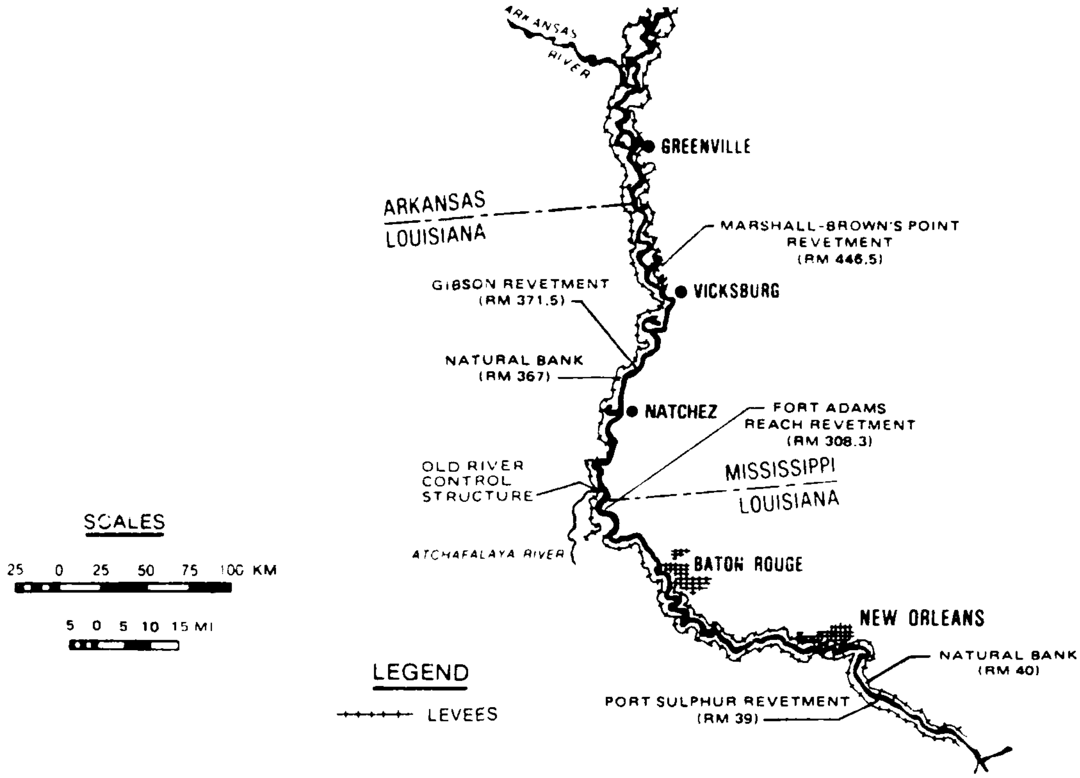

Figure 1. Study area for the revetted and natural bank investigations

area. Near Natchez, Mississippi, the Gibson Revetment (RM 369-373) and the natural bank immediately downstream (RM 366-369) were chosen for study. In the Fort Adams area, near the Mississippi-Louisiana state line, the Fort Adams Revetment was sampled (RM 307-310). In the vicinity of Port Sulphur, the Port Sulphur Revetment (RM 39-43) and the natural bank immediately across the river (RM 40-42) were investigated.

12. Natural banks on the Lower Mississippi River are generally steep, and they are often actively eroding, though erosion rates vary widely depending upon hydrologic and geologic conditions. Substrates are comprised of consolidated clays and silts of low plasticity, often interspersed with sand layers or point bar deposits. Fallen trees and snags are common. Current speeds are generally high; however, turbulence caused by fallen trees, bank friction, and bankline irregularities is high, and upstream flow and eddies are common (Cobb and Clark 1981).

13. Revetted banks are graded to a relatively uniform slope prior to placement of the ACM or riprap. Although the revetment material initially forms the entire bank substrate, coarse bedload sediments are often deposited on the lower revetment, and finer sediments may be deposited on the upper revetment. Fallen trees and snags are uncommon. The bankline is more regular than that of natural banks, and current speeds near the bank are similar to those of the main channel. Eddies may be present, however, and they may sometimes be quite large.

PART III: METHODS

14. The five banks were each sampled during both summer and fall 1985. Two to three days were required to complete sampling in each season. Beginning sampling dates for the three river reaches were: Natchez, 22 June and 8 October; Fort Adams, 10 July and 10 October; Port Sulphur, 30 June and 30 September. Due to high river stages, some fall macroinvertebrate samples at Natchez and Fort Adams revetments were postponed until 22 January 1986. Summer macroinvertebrate samples at Natchez were also delayed slightly, until 9 July.

15. River stage was dropping rapidly during the summer sampling. Gauge height at Natchez was 30.7 ft on 22 June and had declined to 21.0 ft by 9 July. No gauge height data were available at Port Sulfur during the period encompassing our summer sampling. Fall gauge heights were relatively constant, averaging about 14 ft at Natchez in early October, and about 2 ft at Port Sulphur. Gauge height at Natchez was 17.0 ft on 23 January 1986.

Physical-Chemical

16. At each bank five equally spaced transects (designated by letters A-E) running perpendicular to the bank were established, along which were situated three sampling stations: one near the bank in less than 1.5 m of water; one nearer the main channel at a depth of at least 7.0 m; and one station intermediate between the deep and shallow pair.

17. Current speed and direction were measured at 2-m intervals from surface to bottom at each station using an Endeco meter. Temperature, dissolved oxygen concentration, conductivity, and pH were measured in situ at 2-m intervals from the surface to the bottom at the three stations on the upstream, middle, and downstream transects using a Hydrolab 8000 unit. Water samples were collected from 1 m below the surface and 1 m above the bottom at each station on the upstream, middle, and downstream transects. Samples were iced or fixed, as appropriate, and analyzed in the laboratory for total solids, suspended solids, and total organic carbon.

18. Divers were used to "walk down" each transect at the Gibson and Port Sulphur revetments to assess the depth and extent of sediment deposition. The divers recorded the depth of sediment at 0.5-m intervals, and they collected

sediment cores for grain-size analysis at three evenly spaced points along each transect. Sediment grain sizes were grouped into five general categories: (a) particles larger than 4.76 mm constituted gravel; (b) particles 4.76 to 2.00 mm were coarse sand; (c) those 2.00 to 0.42 mm comprised medium sand; (d) particles 0.42 to 0.074 mm were fine sand; and (e) fines were particles less than 0.074 mm.

Biological

Macroinvertebrates

19. Taxonomic composition and density. Macroinvertebrates attached to the surface of the ACM were sampled using a modified Hess sampler, and also by direct removal of entire ACM slabs. Macroinvertebrates were removed from these slabs by brushing and picking in the field. One Hess sample was collected from the inshore station along each transect, and one additional Hess sample was collected between each pair of transects, for a total of 10 near-shore Hess samples per revetted bank. In addition, wherever possible the divers collected Hess samples from a depth of 3 to 5 m on each transect at the Natchez and Port Sulphur revetments. One entire ACM slab was removed from a depth of 0.5 to 1.0 m along each transect at each revetted bank.

20. Two core samples for macroinvertebrates were removed from the sediments underneath each removed ACM slab. If sediment overlayed the revetment, two grab samples, taken with a Shipek dredge, were collected from the center station on each transect. Two Shipek grabs were taken from the center station on each natural bank transect.

21. Two submerged snags were collected from each natural bank transect; snags were taken from a depth of approximately 0.5 m below the surface. Diameters of the snags ranged from about 5 to 12 cm. Invertebrates were brushed and picked from each snag in the field. The snags were returned to the laboratory for measurement of their surface areas.

22. Duplicate drift samples of macroinvertebrates were collected at the near-shore stations on the upstream, middle, and downstream transects at Natchez and Port Sulphur revetments using a 0.5-m, 0.505-mm mesh plankton net. A minimum of 50 m^3 of water was filtered for each sample.

23. All Hess, core, ACM slab, and snag samples were sieved (0.5-mm mesh) in the field and immediately fixed in 5 percent formalin; drift samples were

not sieved prior to fixation. In the lab, invertebrates were transferred to 80 percent ethanol and stained for at least 48 hours with Rose Bengal. Initial sorting was done under 3X circline lamps. Invertebrates were identified to the lowest possible taxon.

24. Biomass. Organisms were placed in a millipore filtering apparatus on pre-tarred glass fiber filters. A mild suction was applied (less than 13 cm of mercury vacuum) to remove excess ethanol and water used for rinsing. The filter, with invertebrates, was placed into pre-tarred aluminum pans. Samples were dried for four hours at 105° C (Weber 1973) then allowed to cool in a desiccator for a minimum of 2-3 hours before weighing. (All Gastropoda and Pelecypoda were moved from their shells before drying.

25. Problems may exist in the various procedures used in preserving samples for taxonomic as well as biomass studies. Studies by some investigators, (Howmiller 1972, Donald and Paterson 1977), have shown that when either 10 percent formalin or 80 percent ethanol are used as preservatives marked decreases in biomass estimates occur. Samples in our study were stored in 10 percent formalin for approximately one week then rinsed and stored in 80 percent ethanol until identifications were completed (approximately 60-90 days). It is possible therefore that our biomass estimates may reflect some error due to the preservatives used in this study.

26. ACM surface modification. The effect of three ACM surface modifications on colonization by benthic macroinvertebrates was tested at the Marshall-Brown's Point and Port Sulphur Revetments using 38 by 36 by 8 cm modified ACM blocks. One modification was to increase total effective colonizable surface area of revetment, and also habitat diversity, by casting grooves in the upper surface of the blocks. Thirteen parallel grooves, 0.6 cm in both width and depth, were spaced at 3.2 cm intervals across the blocks. A second modification involved drilling nine evenly spaced holes, 1.3 cm diam and 0.6 cm deep, in the upper surface of each experimental block. For the final modification, nine commercial "Fish-Hab" units, each consisting of 8 143-cm-long by 0.174-cm-diam plastic strands, were molded into each ACM block.

27. At Vicksburg, 36 experimental blocks were arranged in 12 groups of three, each group containing one grooved block, one block with holes, and one control block. Groups were placed along a 0.25-km stretch of revetment in approximately 1.5-m-deep water on 3 October 1984, and at a river stage of 7.8 ft (Vicksburg gauge). All grooved surface blocks were placed with the

grooves perpendicular to the current. At Port Sulphur, each modified group of blocks also included one incorporating the "Fish-Hab" units. Six groups of four blocks each were placed along the Port Sulphur Revetment on 1 July 1985.

28. Modified blocks were retrieved with the aid of a specially designed "squeeze box" which prevented migration of invertebrates to or from the upper modified surfaces. Invertebrates were brushed and picked from the blocks; the strands of "Fish-Hab" were clipped at the base and placed in plastic bags. Sieving, preservation, and staining techniques were the same as those outlined for other benthic samples.

29. Clearing and staining techniques necessary for identification of oligochaetes and chironomids precludes their further use in making direct biomass estimations. Therefore, after initial counting of the organisms in these taxa, approximately 10 percent were randomly selected for identification. The taxonomic composition of the remainder of the sample, which was used for biomass determinations, was estimated from the 10 percent identified. Organisms were initially dried to constant weight at 105°C; then samples were burned at 550°C in a muffle furnace to constant, ash-free dry weight (usually 1 to 2 hours).

Fishes

30. Data on fish distribution were collected from each natural and revetted bank using boat and backpack electroshockers, hoop nets, and hydroacoustics. At least four samples, each 15 to 20 minutes long, were taken from each bank with the boat electroshocker, using pulsed-a-c current. Voltage was allowed to vary at each site (range 150-260 V) to obtain a current of 5-7 amps. Samples were worked from upstream to downstream, as close to the bank as possible. Depths actually sampled varied with the slope of the bank, and ranged from 1 to 5 m. Five samples, each consisting of 30 m of shoreline, were collected from the shallowest areas at each bank with a battery-powered, pulsed-d-c, backpack electroshocker. The backpack unit was operated at 250 V and 0.6-0.7 amps. Sampling with this gear was effective from the shoreline to a depth of about 1 m. Ten 0.9-m diam, 2.54-cm mesh hoop nets were fished for a single 48-hr period at each bank. One shallow (1.5 m) and one deep (7.5 m) net was placed along each of the five transects. Nets were fished unbaited, with the mouths facing downstream. Although not required by the scope of work, seine hauls were made along each bank wherever conditions permitted. Collections were made with seines of varying lengths, all having 5-mm mesh.

31. Most fishes collected with the boat electroshocker and hoop nets were individually weighed and measured at each site. All fishes captured with the seine and backpack electroshocker, and all small fishes taken with the boat electroshocker, were immediately preserved in 10 percent formalin and processed in the laboratory. Stomach contents were taken from flathead catfish, blue catfish, and freshwater drum at Natchez, and from flathead catfish, blue catfish, red drum, and Atlantic croaker at Port Sulphur.

32. Hydroacoustic data were collected using a BioSonics Model 101 Dual-Beam Echo Sounder operating at 420 kHz, a BioSonics Model 171 Tape Recorder Interface, a Sony SL-2005 Video Cassette Recorder, an EPC Model 1600 Chart Recorder, a BioSonics Chart Recorder Interface, a Hitachi Oscilloscope, and a 420 kHz dual-beam transducer mounted in a Endeco Towed Body. The transducer was towed at a constant speed and at a depth of approximately 2 feet. Data were recorded on videocassette tapes and on chart paper (echograms) which were transported to the laboratory for analysis. A detailed description of a typical hydroacoustic system and how it function's is provided by Burczynski (1979).

33. Survey design consisted of a series of transects perpendicular to the shoreline and extending to approximately 100 m into the channel. Three additional transects were run parallel to the shoreline in nearshore, mid-shore, and offshore positions. This design was identical for both revetted and natural banks and was executed in all surveys.

34. Data acquired on videocassette tapes were processed in the laboratory to determine target strengths (relative fish sizes). Equipment used for processing included the Sony VCR, tape recorder interface, BioSonics Model 181 Dual-Beam Processor, and an IBM personal computer. Echograms were digitized to develop data sets for determining fish densities and spatial fish distributions at each study site.

35. It is important to note that the traditional gears (electroshockers and nets) and the hydroacoustic system effectively sampled different areas along each bank. The boat electroshocker collected fish primarily from depths of about 4 m or less, which effectively limited its use in this study to areas immediately adjacent to the bank. Seines and the backpack electroshocker were, obviously, limited to wadable depths, usually 1 m or less. The use of hoop nets is not generally limited by depth; however, they sample only that area within about 1 m of the bottom. Hydroacoustic systems complement the use

of traditional gears primarily by sampling relatively deep, open-water areas. Hydroacoustics is effective at depths greater than about 2 m, and cannot effectively delineate fish within 1.5 m of the transducer, and therefore its area of coverage overlaps very little with that of the traditional gears.

Analytical

36. Fish, macroinvertebrate, and water quality data were evaluated by analysis of variance (ANOVA) to determine if there were differences among channels or between months of sampling, or trends from upstream to downstream or from inshore to offshore at each bank. Water quality variables were additionally examined for differences due to depth. For boat and backpack electroshocker, hoop net, and seine samples we evaluated the per sample numbers (C/f) and weights (C/y) of all species combined. For the macroinvertebrate samples we evaluated the total per sample number of organisms and taxa. For the ACM modification study, the actual surface area of the blocks (including the additional area added by the grooves) was used in calculating density and biomass. Fish and benthic data were log transformed prior to analysis.

37. Hydroacoustic survey data were used to evaluate four characteristics of the fish community associated with revetment and natural bank study sites. These were the following: (a) mean density of all fish, (b) horizontal distribution from the shore to 100 m into the channel, (c) vertical distribution in the water column, and (d) relative size distribution.

38. The density of fish at each study site was estimated as the number of fish per hectare (10,000 square metres of river surface area. Estimates were made using from 17 to 44 transects per site, each extending from shore to about 100 m into the channel in a direction perpendicular to the bank. Targets on each transect were weighted by $1/(2*R*\tan(\theta/2))$ as an adjustment for increased sample area at increased range (R) from the transducer. For these calculations an effective beam angle (θ) of 7.5 degrees was used. This corresponded to the angle at which a median sized target of -48 db would return an echo equal in strength to the minimum acoustic size for a countable target (-58 db). Weighted counts were then totaled for each transect to get a per transect number of fish per 100 m^2 surface area. Transect totals were then multiplied by 100 to scale values to a per hectare basis.

Mean density and standard error of the estimate were computed from per transect density values using standard formulae.

39. Comparisons of mean density among the 5 sites and between seasons were made using an ANOVA. A completely randomized model involving 10 site by season combinations was fitted to the data. Transect density values were transformed prior to analysis by taking the logarithm of 0.5 plus the transect density. Specific comparisons of particular interest were made as linear comparisons from the analysis of variance.

40. Average horizontal distribution of fish from shore to about 100 m into the channel was computed using data from the perpendicular transects. Data from all transects at a site were pooled and the frequency of fish in 10 m distance intervals was computed using digitized measurements of the horizontal distance of each target from shore. Horizontal distributions were constructed using all targets at least -58 db or larger in size.

41. Vertical and size distribution of fishes were both evaluated using data extracted from the three transects extending parallel to shore in nearshore, midshore, and offshore positions. Vertical distribution summaries were prepared from digitized depth measurements taken from fish leaving echo traces on the chart record. Measurements of fish depth and corresponding river bottom depth were taken for each target in the data. For each fish, its depth in the water column and corresponding depth of the bottom were classified into 2 m depth intervals starting near the time varied gain (TVG) range threshold at 1.5 m and ending at the deepest depth interval of 33.5-35.5 m. All targets occurring at the same bottom depth were combined. A depth distribution profile summarizing the percentage of fish in 2 m intervals from near surface to bottom was then constructed wherever there were 20 or more fish available in one of the bottom class intervals. Each fish target was weighted by 1/R to adjust for the conical shape of the acoustical sampling beam, and the depth distribution was computed from the resulting adjusted counts.

42. Size of targets was estimated using data from the parallel transects. Measurements of target strength was made using the Biosonics Model 181 Dual-Beam Processor. Aided by operator entered parameters, the processor separated single fish from unusable multiple fish echoes, estimated the position of each single target both in depth and number degrees otf axis, and calculated a target strength adjusted for target position in the acoustic beam. Target sizes measured by the Processor in mv were converted to decibels (db).

The smallest target processed was set to a threshold of 300 mv (-58db). A regression relationship from the target strength to fish length has been developed by Love (1971) using data from 8 species of fish and literature reports on 16 other species. The conversion from decibels to centimetres was given as

$$\mathrm{Log}\ (L) = 0.052*TS + 0.047*\log(f) + 3.246$$

where L = fish length in centimetres, TS = target strength in decibels, and f = transmitter frequency (eg., 420 kHz). This relationship was used for conversion of target strength to fish length although it has not been validated for all Mississippi River species. The relative frequency of echo strength values was constructed from Processor output summaries of all targets classified as single fish. Each echo strength was weighted by 1/R2 to adjust for the conical shape of the acoustic beam.

PART IV: RESULTS

Physical-Chemical

Water quality

43. Few consistent differences among stations or depths were noted for any water quality variable at any of the five banks (Tables 1 and 2). Dissolved oxygen was somewhat lower, and the oxidation-reduction potential higher, near the bottom than at the surface in both seasons at the two Port Sulphur banks. Other variables showed some differences from inshore to offshore, or from upstream to downstream along particular banks, but the differences were either very small or were inconsistent.

44. Only very small differences were observed between the revetted and natural bank pairs at Natchez and Port Sulphur at either season. The oxidation-reduction potential tended to be slightly higher along the revetted bank of each pair. At Port Sulphur total organic carbon declined from summer to fall along the revetment, but it increased along the natural bank.

45. Seasonal changes were observed in most water quality variables (Tables 1 and 2). Conductivity and pH increased in fall at all revetted and natural banks, while the oxidation-reduction potential decreased. Temperature declined by 6-8°C in the Natchez and Fort Adams reaches, but decreased only a little over 1°C at Port Sulphur. Dissolved oxygen concentrations increased at all sites except Port Sulphur, where values were similar to those found in summer. Suspended solids, total solids, and total organic carbon decreased at all except the Port Sulphur Natural Bank, where the total organic carbon increased.

Sediments

46. Gibson Revetment. A considerable layer of sediment overlaid the ACM on three of the five diver transects in June at the Gibson Revetment (Figure 2). All three of these transects were in areas of relatively slow currents, A and D in large eddies and E in a relatively straight, though protected reach. Fines comprised nearly three-fourths of the sediments by weight overall (Table 3), but variation among individual samples was high (Figure 2). No overlaying sediment was observed on transect B, and only occasional light patches were observed on transect C. Both these transects were

Table 1

Means and Ranges for Water Quality Variables Measured at Revetted and Natural Banks in the Lower Mississippi River

Bank	pH	Specific Conductance (umho/cm)	Redox Potential (mv)	Dissolved Oxygen (mg/ℓ)	Temperature (°C)
		Summer 1985			
Gibson Revetment	7.4 (7.2-7.6)	374 (372-377)	294 (291-301)	6.5 (6.3-6.8)	25.2 (25.1-25.3)
Natchez Natural Bank	7.3 (7.2-7.4)	375 (374-377)	279 (270-292)	6.5 (6.2-6.7)	25.2 (*)
Fort Adams Revetment	7.6 (7.5-7.6)	431 (426-446)	285 (284-287)	6.5 (6.2-6.7)	27.7 (27.6-27.8)
Port Sulphur Revetment	7.2 (7.0-7.3)	412 (410-413)	322 (304-333)	5.9 (5.7-6.2)	26.8 (*)
Port Sulphur Natural Bank	7.2 (7.2-7.4)	412 (410-414)	298 (280-324)	6.0 (5.8-7.0)	26.8 (26.8-26.9)
		Fall 1985			
Gibson Revetment	7.8 (7.6-7.9)	470 (468-473)	257 (251-264)	7.9 (7.6-8.0)	19.1 (19.1-19.2)
Natchez Natural Bank	7.8 (7.7-8.0)	470 (469-472)	268 (263-274)	7.8 (7.4-8.0)	19.2 (19.2-19.3)
Fort Adams Revetment	7.7 (7.6-8.0)	470 (467-472)	216 (198-236)	7.9 (7.9-8.0)	19.6 (19.6-19.8)
Port Sulphur Revetment	7.3 (7.2-7.4)	493 (479-583)	236 (212-254)	6.1 (5.8-6.4)	25.5 (25.3-25.5)
Port Sulphur Natural Bank	7.4 (7.3-7.5)	471 (469-472)	246 (223-260)	6.0 (5.9-6.4)	25.5 (25.5-25.6)

* No variation among stations.

Table 2

Means and Ranges for Dissolved, Suspended, and Total Solids, and Total Organic Carbon at Revetted and Natural Banks in the Lower Mississippi River

Bank	Dissolved Solids (mg/l)	Suspended Solids (mg/l)	Total Solids (mg/l)	Total Organic Carbon (mg/l)
		Summer 1985		
Gibson Revetment	280 (254-304)	204 (180-229)	483 (466-516)	7.5 (7.2-8.3)
Natchez Natural Bank	273 (257-292)	193 (180-219)	466 (445-479)	8.2 (7.3-10.0)
Fort Adams Revetment	320 (297-351)	68 (49-97)	388 (358-425)	4.7 (4.1-5.3)
Port Sulphur Revetment	287 (277-297)	80 (60-95)	366 (349-382)	5.9 (4.9-8.0)
Port Sulphur Natural Bank	294 (271-314)	98 (52-176)	393 (323-490)	5.4 (4.3-7.6)
		Fall 1985		
Gibson Revetment	302 (296-331)	74 (49-94)	377 (357-399)	5.0 (4.6-5.4)
Natchez Natural Bank	305 (289-314)	80 (71-91)	385 (380-388)	5.4 (5.0-5.7)
Fort Adams Revetment	301 (290-318)	73 (63-88)	374 (367-398)	5.6 (5.0-6.3)
Port Sulphur Revetment	310 (247-343)	<10 --	320 (275-353)	3.8 (3.7-4.0)
Port Sulphur Natural Bank	315 (280-357)	<10 --	325 (290-348)	3.8 (3.3-4.2)

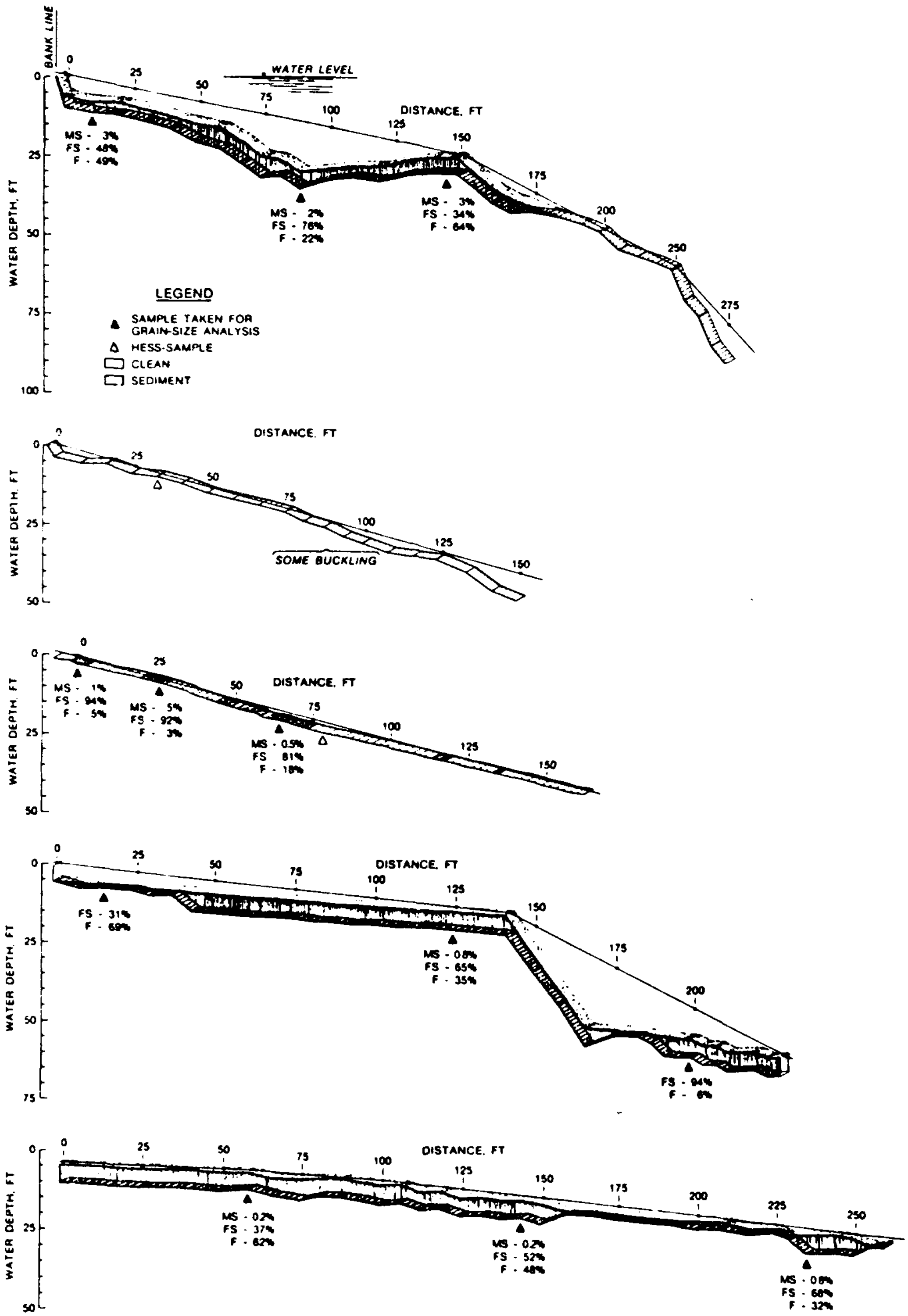

Figure 2. Sediment deposition observed along five diver transects made at Gibson Revetment during June 1985. Triangles indicate approximate positions of sediment samples collected by the divers; MS = medium sand, FS = fine sand, and F = fines

Table 3

Composition of the Substrate Along Diver Transects at Gibson and Port Sulphur Revetments, Lower Mississippi River

	Gibson Revetment		Port Sulphur Revetment	
	June 1985	Jan 1986	June 1985	Jan 1986
Length of Revetment Surveyed (ft)	1,025	850	825	805
Length of Revetment Overlaid With Sediment (ft)	655	470	345	342
Percent of Revetment Overlaid with Sediment	64	55	42	42
Sediment Grain-Size Composition (Percent)				
Coarse Sand	-	-	0.1	-
Medium Sand	0.2	0.2	0.2	0.2
Fine Sand	25.8	54.3	24.2	25.4
Fines	74.0	45.5	75.4	74.7

located along relatively straight sections of revetment where current speeds were relatively high.

47. In February 1986, sediment deposition was generally sparser than in June 1985 (Figure 3), and only the two downstream-most transects were covered over for most of their lengths. The fraction of revetment overlaid by sediment declined to 55 percent in February from 64 percent in June. Overall sediment composition consisted of nearly equal percentages of fine sand and fines (Table 3), although again station-to-station variability was high.

48. Fort Adams Revetment. Divers were not used to assess sediment distribution at Fort Adams Revetment. The difficulty encountered in obtaining Shipek grab samples containing sufficient sediment, however, indicated that sediment deposition was relatively light overall. Field observations of the

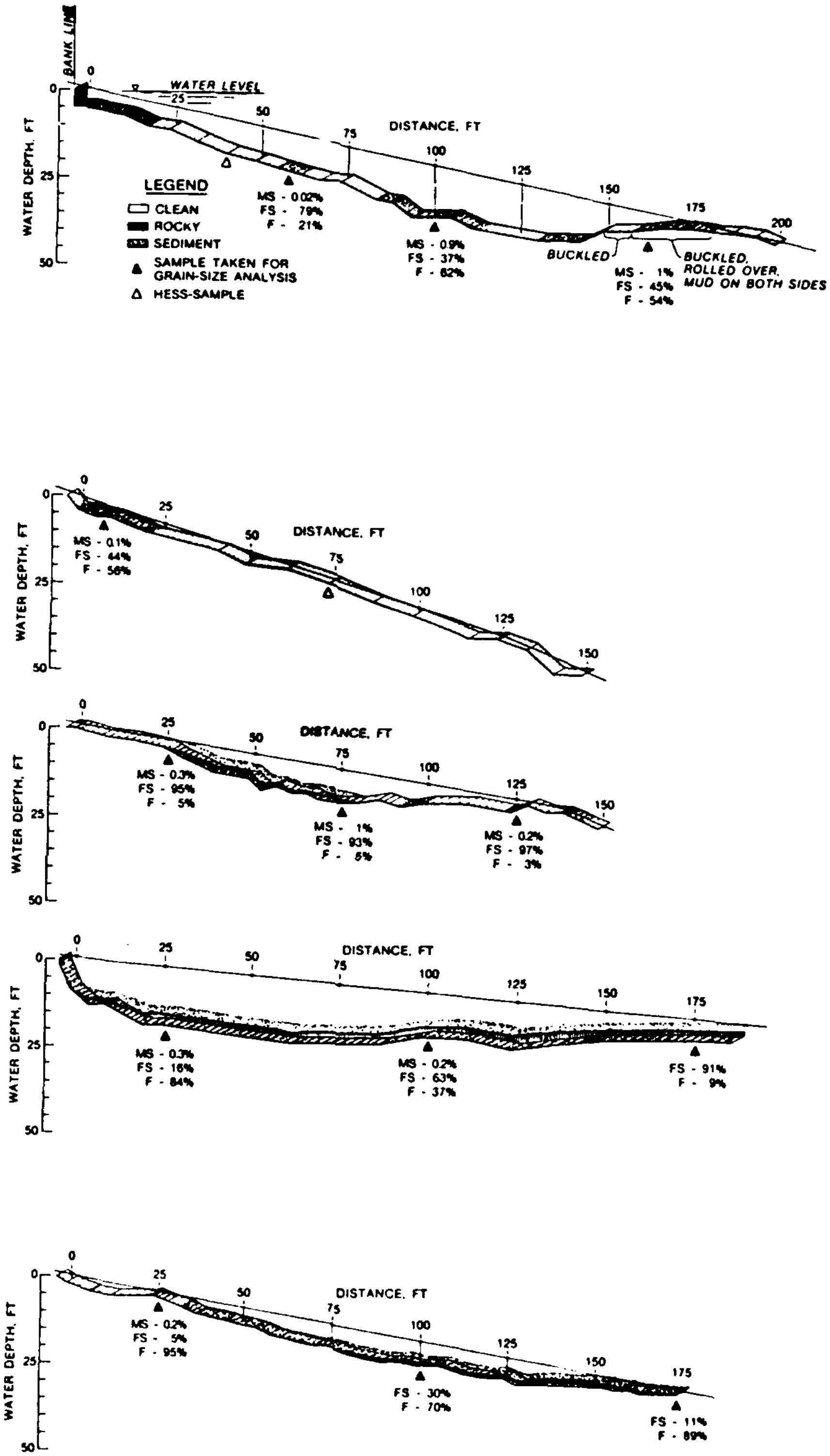

Figure 3. Sediment deposition observed along five diver transects made at Gibson Revetment during February 1986. Triangles indicate approximate positions of sediment samples collected by the divers; MS = medium sand, FS = fine sand, and F = fines

sediments that were obtained suggested that medium and fine sands were the dominant particle sizes.

49. Port Sulphur Revetment. Only the middle and downstream transects at Port Sulphur Revetment were overlaid with an appreciable extent of sediment in June, transects A, B, and D containing primarily clean ACM (Figure 4). The overall fraction of revetment covered by sediment was 42 percent, with fines dominating overall (Table 3) and at most stations (Figure 4).

50. In February, transects C and D had a relatively large percentage of the ACM covered by sediment (Figure 5), while at the other three transects comparatively light coverage was observed. Overall grain-size composition, and the overall percentage of ACM covered by sediment, changed little from June (Table 3).

Currents

51. Gibson Revetment. Current speeds were relatively high along this bank during summer (Table 4), averaging over 61 cm/sec. Variability in mean current speed among the 15 stations was considerable, as was variability in current speed with depth at many individual stations. Both the highest discrete current reading, and the largest overall range of current speeds, was observed along this bank. Currents tended to increase with distance from shore (Table 4), and to decrease from the surface toward the bottom (Figure 6). Plots of "average" current direction (Figure 6) showed a large number of shoreward-oriented vectors, illustrating the great variability in flow pattern along this bank. The vertical variation in current direction observed at many individual stations (Table 5) also indicated the complexity of flow pattern. In general, these variable patterns substantiated our field observations of numerous eddies at this revetment.

52. In fall, currents were somewhat higher overall than in summer (Table 4), although the range of observed values was lower. Again, currents tended to increase from the bank toward the main channel, and to decrease from the surface toward the bottom (Figure 7). "Average current direction vectors (Figure 7), and the variation observed about these vectors at individual stations (Table 5), indicated less complexity in current pattern in fall.

53. Natchez Natural Bank. Mean current speed in summer, and the range of speeds (Table 4), was similar to that observed at Gibson Revetment, which was located immediately upstream of this natural bank. An increase in current speed from inshore and offshore, and a decrease from bottom to surface, was

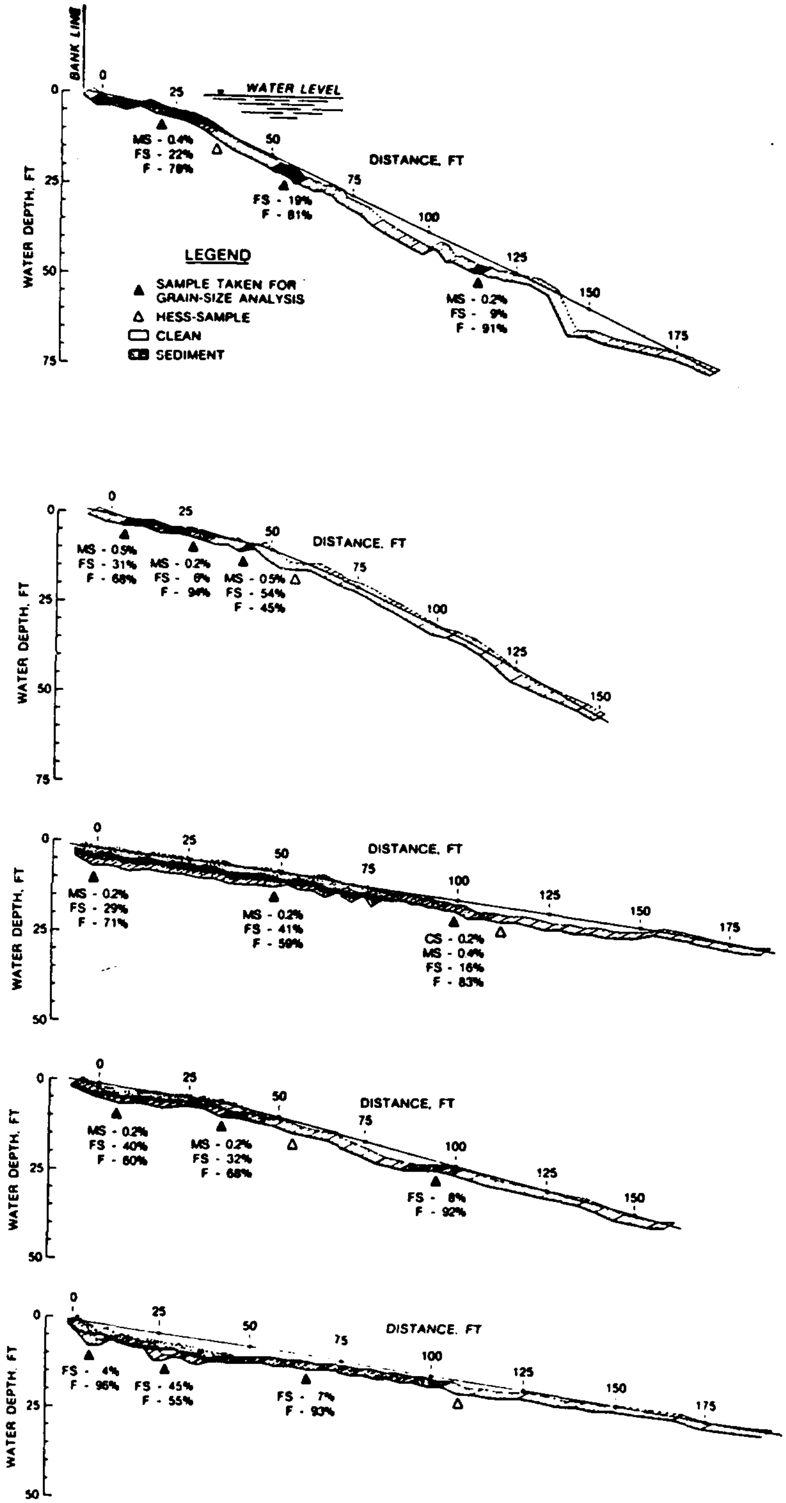

Figure 4. Sediment deposition observed along five diver transects made at Port Sulphur Revetment during June 1985. Triangles indicate approximate positions of sediment samples collected by the divers; MS = medium sand, FS = fine sand, and F = fines

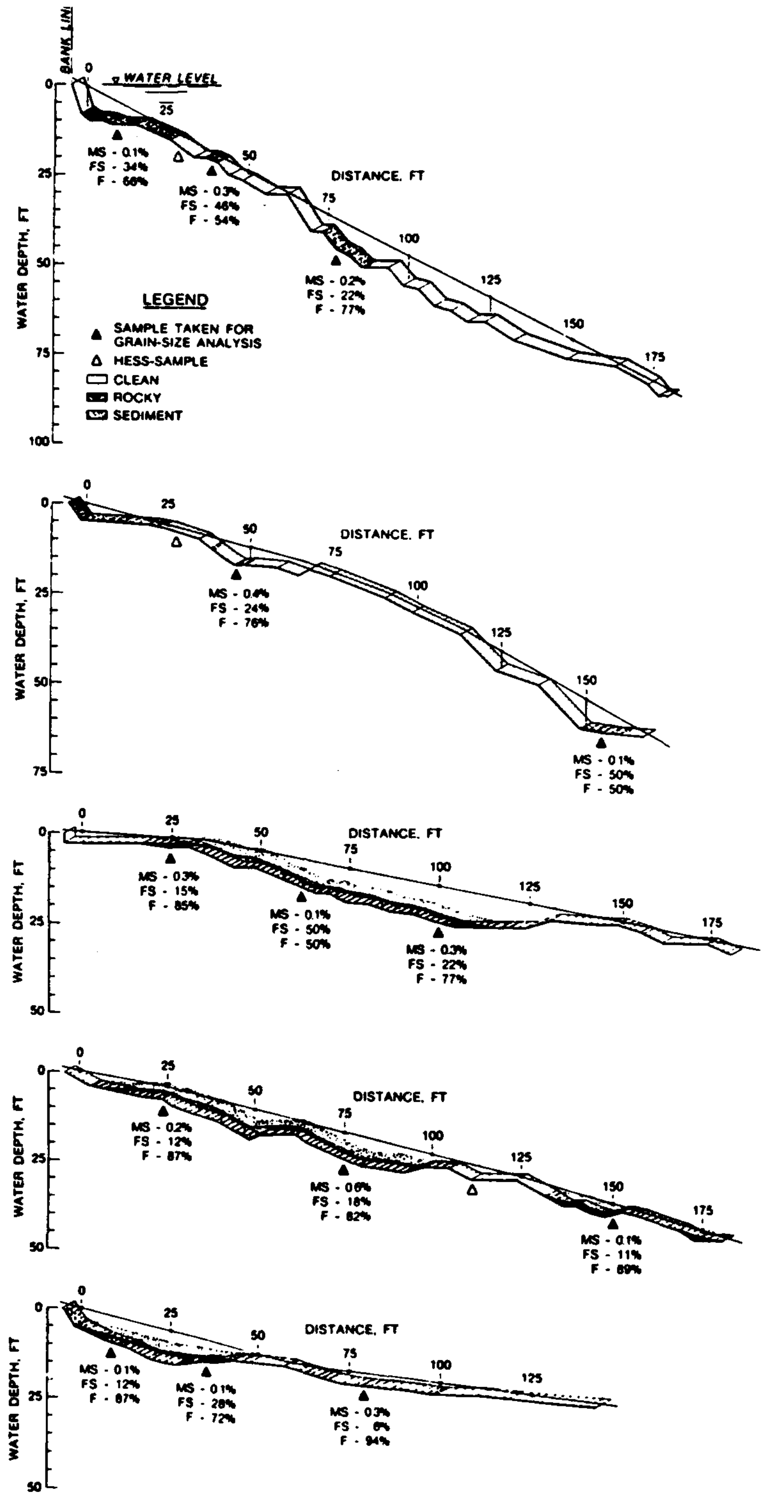

Figure 5. Sediment deposition observed along five diver transects made at Port Sulphur Revetment during February 1986. Triangles indicate approximate positions of sediment samples collected by the divers; MS = medium sand, FS = fine sand, and F = fines

Table 4

Means and Ranges of Current Speeds Recorded for Five Banks in the Lower Mississippi River, 1985*

Bank Station	Summer Current, cm/sec Highest	Summer Lowest	Summer Mean	Fall Current, cm/sec Highest	Fall Lowest	Fall Mean
Gibson Revetment						
A01	15	15	15	15	15	15
A02	139	98	116.6	30	30	30
A03	185	82	106.3	128	85	107.6
B01	67	67	67	52	52	52
B02	98	82	91.8	64	37	52
B03	175	149	158.5	116	76	97.9
C01	57	57	57	58	58	58
C02	93	41	70.3	113	110	111.2
C03	139	108	126.7	131	70	104.5
D01	10	10	10	30	30	30
D02	26	10	16	40	18	28.3
D03	124	82	92.8	137	98	116
E01	5	5	5	46	46	46
E02	72	51	60.6	104	82	93
E03	93	15	59.8	122	70	95.8
Overall Mean			61.6			69.2
Natchez Natural Bank						
A01	31	31	31	52	52	52
A02	98	57	73.2	119	70	103
A03	93	41	71.	128	70	101.2
B01	82	82	82.	131	131	131
B02	98	72	83.5	134	125	129.5
B03	88	41	70.8	146	113	126
C01	15	15	15	91	91	91
C02	149	72	101.8	76	91	83.5
C03	108	82	97.8	149	107	127
D01	15	15	15.	40	40	40
D02	51	31	41.	88	67	76.6
D03	113	72	93.3	122	61	98.8
E01	57	57	57.	18	18	18
E02	93	57	73.	43	27	33.3
E03	113	41	79.9	85	43	65.5
Overall Mean			65.7			85.1
Fort Adams Revetment						
A01	15	15	15	43	43	43
A02	40	27	31.6	98	73	87.2

(Continued)

* Highest and lowest current speeds indicated are those recorded for the vertical profile (2-m intervals) at each station. Station 1 is the nearshore station on each transect; station 3 is the most offshore.

(Sheet 1 of 3)

Table 4 (Continued)

Bank Station	Summer Current, cm/sec Highest	Lowest	Mean	Fall Current, cm/sec Highest	Lowest	Mean
Fort Adams Revetment (Cont'd)						
A03	46	21	35.4	110	58	83.1
B01	24	24	24	58	58	58
B02	30	21	26.5	107	82	91.4
B03	40	18	30.9	110	85	94.4
C01	12	12	12	15	15	15
C02	37	27	33.7	104	91	98.3
C03	43	18	25.4	113	70	89.3
D01	58	58	58	43	43	43
D02	40	27	34.2	104	82	96
D03	40	18	30.5	107	70	86.3
E01	52	52	52	82	82	82
E02	107	43	77	122	88	107.5
E03	46	24	38	119	64	98.5
Overall Mean			35.2			78.2
Port Sulphur Revetment						
A01	18	18	18	37	34	35.5
A02	27	15	23.1	59	43	51.1
A03	30	24	26.3	58	30	45.7
B01	15	15	15	49	37	43
B02	37	15	26.9	73	46	57.1
B03	30	18	25.3	67	37	52.2
C01	12	12	12	43	40	41.5
C02	30	21	24.4	79	55	61.4
C03	40	18	31	79	34	54.2
D01	12	12	12	46	37	41.5
D02	43	27	33.7	79	49	59.5
D03	34	21	25.7	79	46	57.7
E01	15	15	15	43	40	41.5
E02	30	21	25.8	79	49	68.7
E03	37	18	22.2	82	40	61.3
Overall Mean			21.2			51.4
Port Sulphur Natural Bank						
A01	18	18	18	21	21	21
A02	27	18	21	58	37	48.2
A03	30	21	26	76	43	49.2
B01	27	27	27	15	6	10.5
B02	43	34	39	55	30	49.3
B03	46	18	30.2	70	46	53.6

(Continued)

(Sheet 2 of 3)

Table 4 (Concluded)

Bank Station	Summer Current, cm/sec			Fall Current, cm/sec		
	Highest	Lowest	Mean	Highest	Lowest	Mean
Port Sulphur Natural Bank (Cont'd)						
C01	9	9	9	34	30	32
C02	37	18	24.2	52	40	45.6
C03	34	15	23.3	55	40	45.7
D01	27	27	27	21	21	21
D02	27	24	26.4	46	27	33.9
D03	24	12	18.9	82	43	58.9
E01	24	24	24	30	24	27
E02	18	12	16.8	27	21	23
E03	27	15	19.1	52	21	37.3
Overall Mean			23.3			37.2

(Sheet 3 of 3)

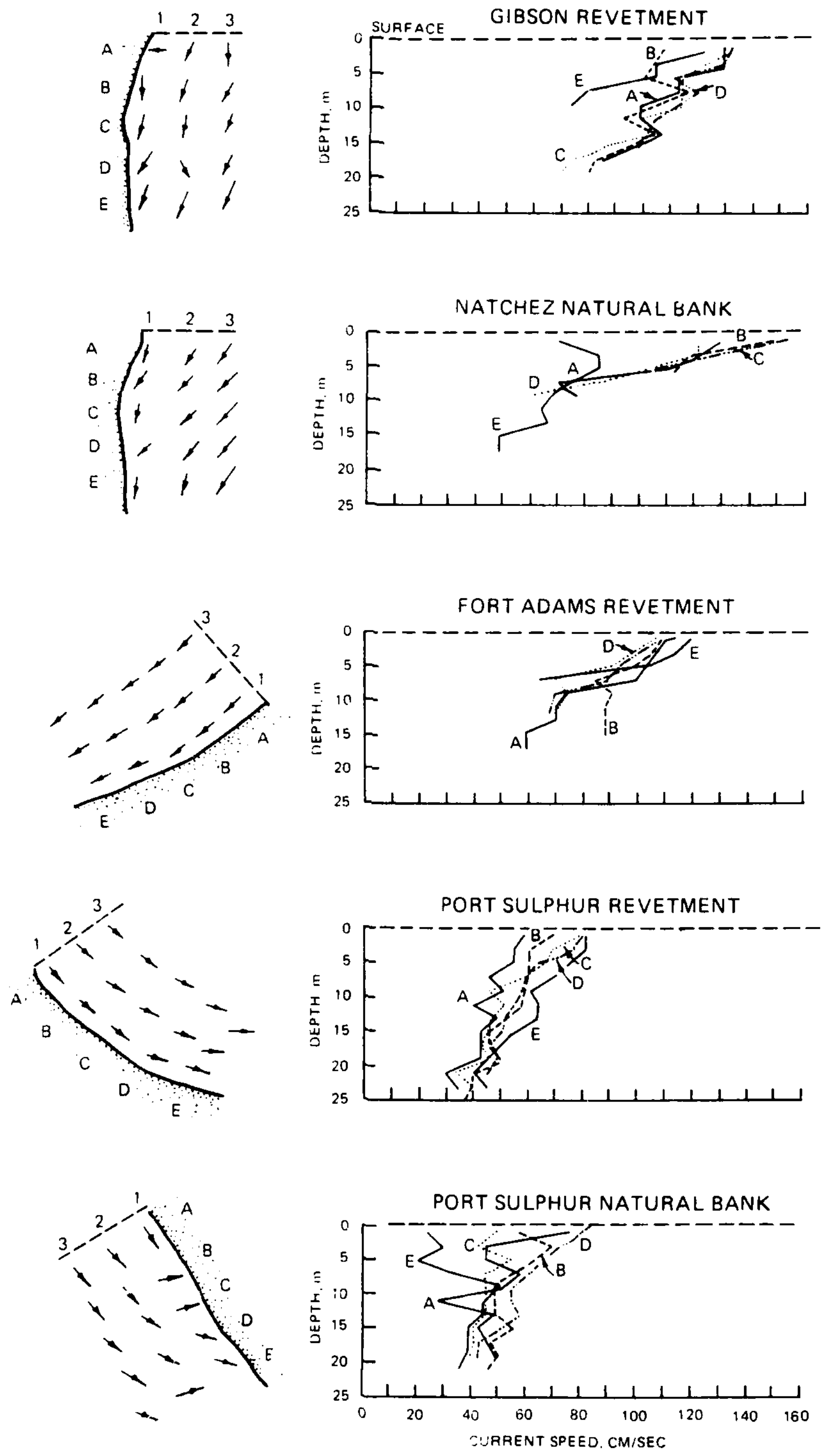

Figure 6. Average current direction vectors (left) and vertical current profiles (right) observed at stations along three revetments and two natural banks in the Lower Mississippi River, June 1985. Transects are indicated by letters A-E, and stations by numbers 1-3. All figures are arranged so that north is at the top of the page. Vertical current speed profiles are for the station farthest offshore at each transect

Table 5

Average Current Direction and Vertical Variation in Direction, in Degrees, at Stations Along Five Banks in the Lower Mississippi River, 1985

	Summer		Fall	
Bank Station	Average Current Direction	Directional Variation in Vertical Profile	Average Current Direction	Directional Variation in Vertical Profile
Gibson Revetment				
A01	195	--*	270	--
A02	258	240-272	273	250-300
A03	254	225-270	185	165-225
B01	230	--	176	--
B02	238	225-255	195	185-195
B03	275	255-285	207	195-218
C01	220	--	190	--
C02	229	200-255	189	152-210
C03	264	255-280	194	188-200
D01	195	--	215	--
D02	193	185-200	155	140-170
D03	247	226-310	198	180-210
E01	195	--	195	--
E02	226	210-240	202	200-208
E03	223	195-265	202	190-218
Natchez Natural Bank				
A01	205	--	200	--
A02	234	220-250	217	210-220
A03	228	210-245	218	198-235
B01	250	--	210	--
B02	251	225-275	224	220-228
B03	243	221-268	221	220-222
C01	185	--	185	--
C02	250	240-255	229	222-235
C03	249	240-255	218	215-220
D01	190	--	230	--
D02	216	210-227	215	205-222
D03	256	240-270	217	212-220
E01	195	--	188	--
E02	237	225-250	194	185-200
E03	243	225-268	208	198-218

(Continued)

* No variation at 01 stations on any transect; water depth at these stations permitted only one current speed and direction determination.

Table 5 (Continued)

Bank Station	Summer		Fall	
	Average Current Direction	Directional Variation in Vertical Profile	Average Current Direction	Directional Variation in Vertical Profile
Fort Adams Revetment				
A01	232	--	228	--
A02	225	216-230	219	210-230
A03	231	212-250	214	195-225
B01	234	--	232	--
B02	225	210-252	217	212-222
B03	226	220-238	224	215-238
C01	230	--	215	--
C02	236	228-254	220	218-222
C03	227	200-266	226	222-228
D01	252	--	248	--
D02	236	232-240	234	228-240
D03	231	220-240	220	215-230
E01	230	--	238	--
E02	239	230-244	227	225-230
E03	244	209-262	223	200-232
Port Sulphur Revetment				
A01	150	--	139	--
A02	138	130-140	128	118-150
A03	137	115-153	122	100-140
B01	142	--	141	--
B02	138	125-145	112	105-135
B03	131	103-160	120	105-135
C01	121	--	143	--
C02	138	125-145	114	100-125
C03	116	60-116	116	102-138
D01	102	--	108	--
D02	112	98-125	101	90-112
D03	109	100-125	104	95-120
E01	207	--	113	--
E02	102	60-135	92	82-102
E03	103	88-135	97	85-110
Port Sulphur Natural Bank				
A01	155	--	148	--
A02	157	145-170	136	119-152
A03	142	112-172	137	122-145
B01	160	--	78	--
B02	142	100-170	147	138-155
B03	150	128-160	141	125-156
C01	155	--	73	--
C02	149	148-150	124	110-142

(Continued)

Table 5 (Concluded)

Bank Station	Summer Average Current Direction	Summer Directional Variation in Vertical Profile	Fall Average Current Direction	Fall Directional Variation in Vertical Profile
C03	143	125-158	123	125-158
D01	130	--	113	--
D02	134	125-142	115	95-125
D03	127	98-145	123	112-135
E01	138	--	105	--
E02	133	125-148	70	58-108
E03	128	95-162	112	92-132

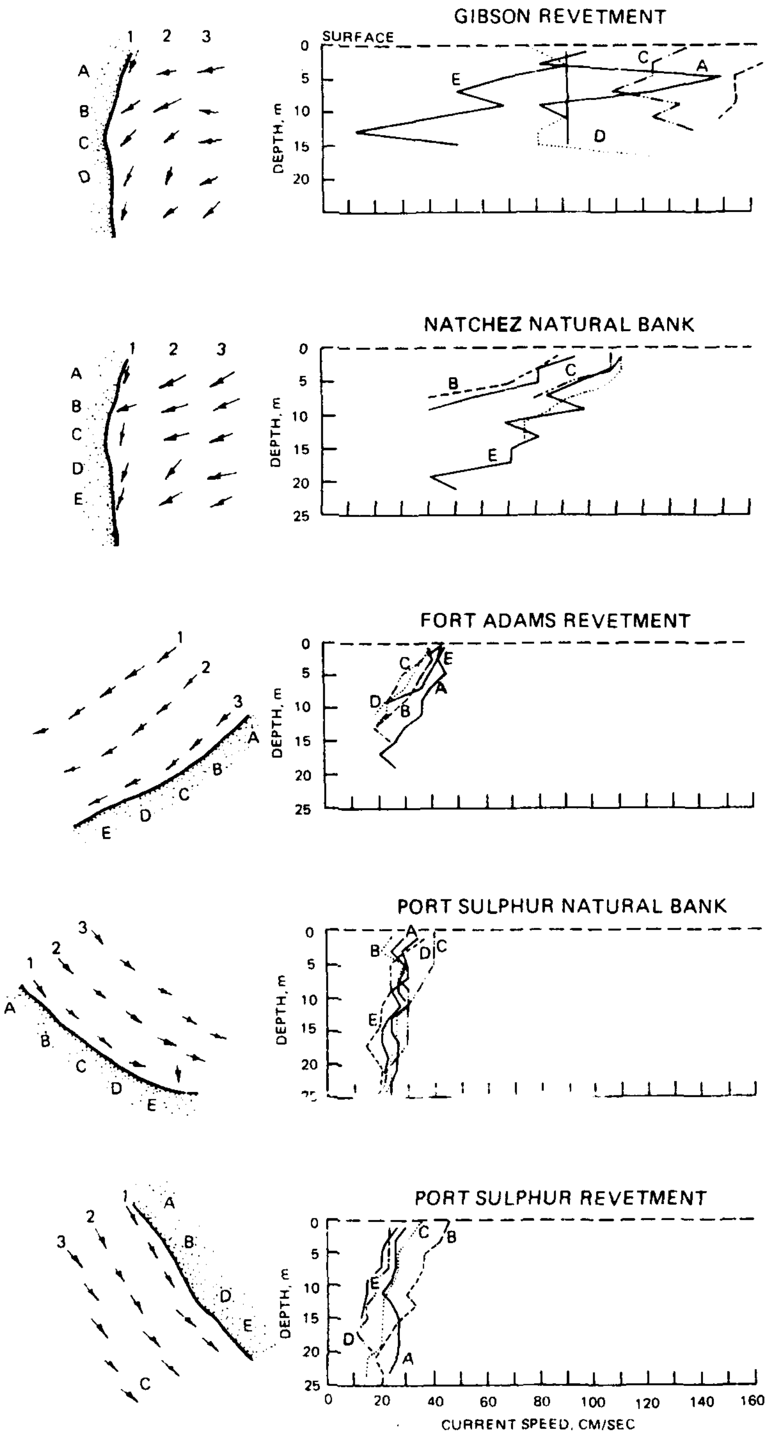

Figure 7. Average current direction vectors (left) and vertical current profiles (right) observed at stations along three revetments and two natural banks in the Lower Mississippi River, October 1985. Transects are indicated by letters A-E, and stations by numbers 1-3. All figures are arranged so that north is at the top of the page. Vertical current speed profiles are for the station farthest offshore at each transect

typical. Variability in "average" current vectors (Figure 6), and the vertical differences observed (Table 5), were also similar, indicating a general shoreward current orientation (and numerous eddies).

54. Mean current speed increased from summer to fall (Table 4), with the same general trends observed as in summer. Current direction vectors were only slightly different from summer (Figure 7; Table 5).

55. Fort Adams Revetment. Current speeds along this revetment were comparatively low in summer (Table 4). A trend of increasing current with distance from shore was observed for the upstream three transects, but not generally for the downstream two. No large eddies were noted while sampling, and current direction vectors indicated flow movement parallel to the shore, with little variation (Figure 6; Table 5).

56. Currents were considerably stronger in fall (Table 4), but direction (Figure 7), and consistency of direction (Table 5), were similar to summer.

57. Port Sulphur Revetment. Current speeds were relatively low overall along this bank in summer (Table 4). They were generally slowest along the bank, but only an erratic increase in average speed was observed with distance from the shore. Flow was generally parallel to the bankline (Figure 6) except in the area of the downstream transect, where an eddy was observed. Little variation in direction was observed for any of the vertical profiles (Table 5).

58. In fall, currents were higher than in summer along this bank (Table 4). The shore-to-channel increase in mean current speed was still somewhat erratic. Flow was parallel to the bankline at all stations (Figure 7).

59. Port Sulphur Natural Bank. Like the revetted bank at this site, summer current speeds were quite low here (Table 4). The erratic pattern of increase from shore to channel observed along the revetment was also observed at this natural bank. Direction of flow was parallel to the bank at all stations (Figure 6), and little variability in this pattern was observed with depth (Table 5).

60. In fall, currents were higher, but the same overall pattern of current speeds among stations existed (Table 4). A considerable change in the nearshore current vectors was observed, however, with many of them being shoreward-oriented (Figure 7).

Biological

Fishes

61. Gibson Revetment. A total of 453 fish were taken from the Gibson Revetment site, 304 in summer and 149 in fall (Tables 6 and 7). The total weight of fish was comparable in both seasons, 27 and 28.6 kg, respectively. Thirty-four species (common and scientific names can be found in Table A1) were recorded for the site, 29 in summer and 20 in fall. Hoop nets and the boat electroshocker, gears which sampled larger species most effectively, captured 12 species and 56 fish in summer, and 14 species and 96 fish in fall (Table A2). During summer, blue catfish, flathead catfish, and freshwater drum accounted for 12 of the 14 fish taken in hoop nets; in fall, blue and flathead catfishes were the only species captured with this gear. Fall hoop net C/f dropped slightly compared to summer, and C/y dropped considerably (Table 8). Gizzard shad, threadfin shad, and striped mullet dominated summer boat electroshocker catches, and these same three species, plus common carp and white bass, comprised most of the fall catch. In contrast to hoop nets, C/f and C/y for the boat electroshocker increased about two-fold in fall.

62. Seine and backpack electroshocker samples of small, near-shore fishes produced 24 species and 248 fish in summer, but only 10 species and 53 fish in October (Table A2). Although seining accounted for over 95 percent of the fish taken by these two gears, two species were taken only by the backpack electroshocker (Table A2). Threadfin shad, Mississippi silvery minnow, silver chub, mimic shiner, and white bass accounted for over 82 percent of the summer catch, while in fall threadfin shad, emerald shiner, and silverband shiner were the most abundant species.

63. Gibson Revetment supported a mean density (plus or minus two standard errors (SE) of 772 ± 221 fish per hectare of surface area during the summer survey (Table 9). Targets occurred over the entire area, with 22 of 24 perpendicular transects recording from 1 to 39 targets each. Numbers of fish were greater further from shore, with an estimated 70 percent of the fishes occurring between 65 to 100 m from the bank (Figure 8). Vertical distribution of fishes in the water column depended on distance from the bank. Closer to shore, where bottom depths ranged to 17 m, fishes were distributed uniformly throughout the water column. Where bottom depths were 17 to 27 m, fishes occurred predominantly near the bottom of the river (Figure 9). Target

Table 6

Composition of Fish Catches from Two Natural Banks and Three Revetted Banks on the Lower Mississippi River Summer 1985

Species	Gibson Revetment	Natchez Natural Bank	Fort Adams Revetment	Port Sulphur Revetment	Port Sulphur Natural Bank
Atlantic stingray					15
Longnose gar	3	1			
Spotted gar					1
Shortnose gar	3	2			
American eel	1		1	12	
Skipjack herring	1	3	13	6	
Gizzard shad	15	16	77	1	1
Threadfin shad	118	58	111		2
Bay anchovy					94
Goldeye			3		1
Goldfish			1		
Common carp			6	1	
Mississippi		6			
silvery minnow	19		1		
Speckled chub					
Silver chub	17	17	6		4
Golden shiner	1				
Emerald shiner	2	3	12		3
River shiner	5	8	3		
Pugnose minnow		1			
Ghost shiner	7				
Red shiner	4	1	4		
Silverband shiner	2	2	6		
Weed shiner		2			
Blacktail shiner	3	6	6		
Mimic shiner	15	6			
Bullhead minnow	3	4			
River carpsucker					
Blue sucker					
Blue catfish	7	4	2	2	2
Channel catfish	1	1	1	8	6
Flathead catfish	5	7	23	2	4
Mosquitofish	2				
Blackspotted topminnow		2			1

(Continued)

Table 6 (Concluded)

Species	Gibson Revetment	Natchez Natural Bank	Fort Adams Revetment	Port Sulphur Revetment	Port Sulphur Natural Bank
Bayou killifish					
Brook silverside					1
Inland silverside	10	15	67		
Rough silverside				7	1
Atlantic needlefish				2	1
White bass	35	20	12		
Yellow bass				2	2
Striped bass				2	
Green sunfish		2			
Orangespotted sunfish	1	2			
Bluegill		1	1		
Longear sunfish			1		
Largemouth bass					
White crappie	4	3	1		
Black crappie					
Bluntnose darter			1		
River darter	4				
Sauger	1				
Crevalle Jack					
Pigfish					
Freshwater drum	6	6	6	11	17
Red drum					
Striped mullet	10	6	14	298	10
Freshwater goby					
Southern flounder				3	
Total	304	205	379	347	166

Table 7

Composition of Fish Catches from Two Natural Banks and Three Revetted Banks on the Lower Mississippi River

Fall 1985

Species	Gibson Revetment	Natchez Natural Bank	Fort Adams Revetment	Port Sulphur Revetment	Port Sulphur Natural Bank
Atlantic stingray					
Longnose gar					
Spotted gar					
Shortnose gar	1				
American eel			1	2	
Skipjack herring	1	3	1		1
Gizzard shad	38	47	68		1
Threadfin shad	27	17	17		
Bay anchovy					138
Goldeye		2			
Common carp	7	2	14		
Mississippi silvery minnow			1		
Speckled chub			4		
Silver chub					
Golden shiner					
Emerald shiner		6			
River shiner	9	2			
Pugnose minnow					
Ghost shiner	2				
Red shiner					
Silverband shiner	18	19	2		
Weed shiner					
Blacktail shiner	1	1			
Mimic shiner					
Bullhead minnow			1		
River carpsucker	1	4			
Blue sucker					
Blue catfish	7	20		3	
Channel catfish	6			2	
Flathead catfish	5	16			
Mosquitofish					
Blackspotted topminnow					

(Continued)

Table 7 (Concluded)

Species	Gibson Revetment	Natchez Natural Bank	Fort Adams Revetment	Port Sulphur Revetment	Port Sulphur Natural Bank
Bayou killifish					
Brook silverside	1		1		
Inland silverside	1	6	12		
Rough silverside					
Atlantic needlefish		6			1
White bass	10		12	4	3
Yellow bass				1	
Striped bass				1	2
Green sunfish					
Orangespotted sunfish					
Bluegill	4	1	1		
Longear sunfish	1				
Largemouth bass				1	
White crappie	3				
Black crappie				1	
Bluntnose darter					
River darter					
Sauger			1		
Crevalle Jack					1
Pigfish				1	1
Freshwater drum		7	2	2	6
Red drum				1	
Striped mullet	6	1	35	157	80
Freshwater goby					1
Southern flounder					
Total	149	150	213	176	235

Table 8

Mean Catch-Per-Unit-Effort* by Gear for Five Sites on the Lower Mississippi River

Gear	Summer				
	Gibson Revetment	Natchez Natural Bank	Fort Adams Revetment	Port Sulfur Revetment	Port Sulfur Natural Bank
			Summer		
Hoop nets	1.40 (1,382)	1.44 (984)	1.00 (1,454)	1.80 (571)	3.50 (3,760)
Boat electroshocker	10.50 (3,235)	11.50 (2,078)	29.51 (6,534)	69.20 (15,028)	4.50 (1,690)
Seine	39.17 (45.87)	29.00 (24.76)	35.17 (17.07)	**	21.80 (156.42)
Backpack electroshocker	2.09 (1.78)	0.44 (2.07)	1.38 (20.78)	3.73 (1,023.25)	1.29 (829.85)
			Fall		
Hoop nets	1.00 (345)	0.90 (309)	1.10 (1,628)	1.10 (163)	0.60 (142)
Boat Electroshocker	21.50 (6,253)	21.00 (4,994)	41.25 (17,746)	44.00 (12,872)	23.73 (9,997)
Seine	7.29 (12.61)	9.40 (22.70)	4.60 (129.56)	**	28.00 (6.84)
Backpack electroshocker	0.38 (5.02)	1.75 (28.31)	2.52 (290)	-0- (-0-)	-0- (-0-)

* Given as numbers above, and weight in grams below, in parentheses.
** Gear use precluded at this site.

Table 9

Mean Density of Fish on Revetted and Natural Bank Study Sites Estimated from Hydroacoustic Surveys

Season	Location And Bank Type	Number of Transects	Mean Number of Fish/ha	Standard Error Fish/ha
Summer	Gibson Revetment	24	772	111
	Natchez Natural Bank	21	483	164
	Fort Adams Revetment	42	94	22
	Port Sulphur Revetment	17	54	17
	Port Sulphur Natural Bank	18	204	81
Fall	Gibson Revetment	44	180	40
	Natchez Natural Bank	18	545	254
	Fort Adams Revetment	42	21	10
	Port Sulphur Revetment	38	86	18
	Port Sulphur Natural Bank	32	198	37

strength analysis involving 41 echo returns showed target sizes (Figure 10) ranging from -50 db to -24 db (6 to 132 cm) with a median size of -38 db (25 cm).

64. The fall survey showed 180 ± 79 fish per hectare (Table 9), a statistically significant reduction of 77 percent below mean summer density (Table 10). Fishes were about equally abundant on the revetment at distances from 10 to 90 m from the bank. Median distance from shore for all fishes was near the middle of the revetment at 42 m (Figure 8). Vertically, fish were found predominantly in the lower half of the water column, with 49 to 65 percent of all fishes occurring within 4 m of the bottom (Figure 9). There were almost no fish in the upper half of the water column. Fish size distribution was considerably smaller than in summer (Figure 10). Target strengths measured from 345 echo returns ranged from the lower processing threshold of -58 db to -32 db (2 to 51 cm). Median target size was -50 db (6 cm).

65. Natchez Natural Bank. A total of 355 fish were collected from the Natchez Natural Bank study site, 205 in summer and 150 in fall (Tables 6 and 7). A slightly higher overall weight of fish was taken in fall. Thirty-one species were taken, 28 and 18 in the two seasons. Hoop nets and the boat electroshocker captured 11 species and 59 fish in summer, and 11 species and 93 fish in fall (Table A3). Blue catfish, flathead catfish, and freshwater

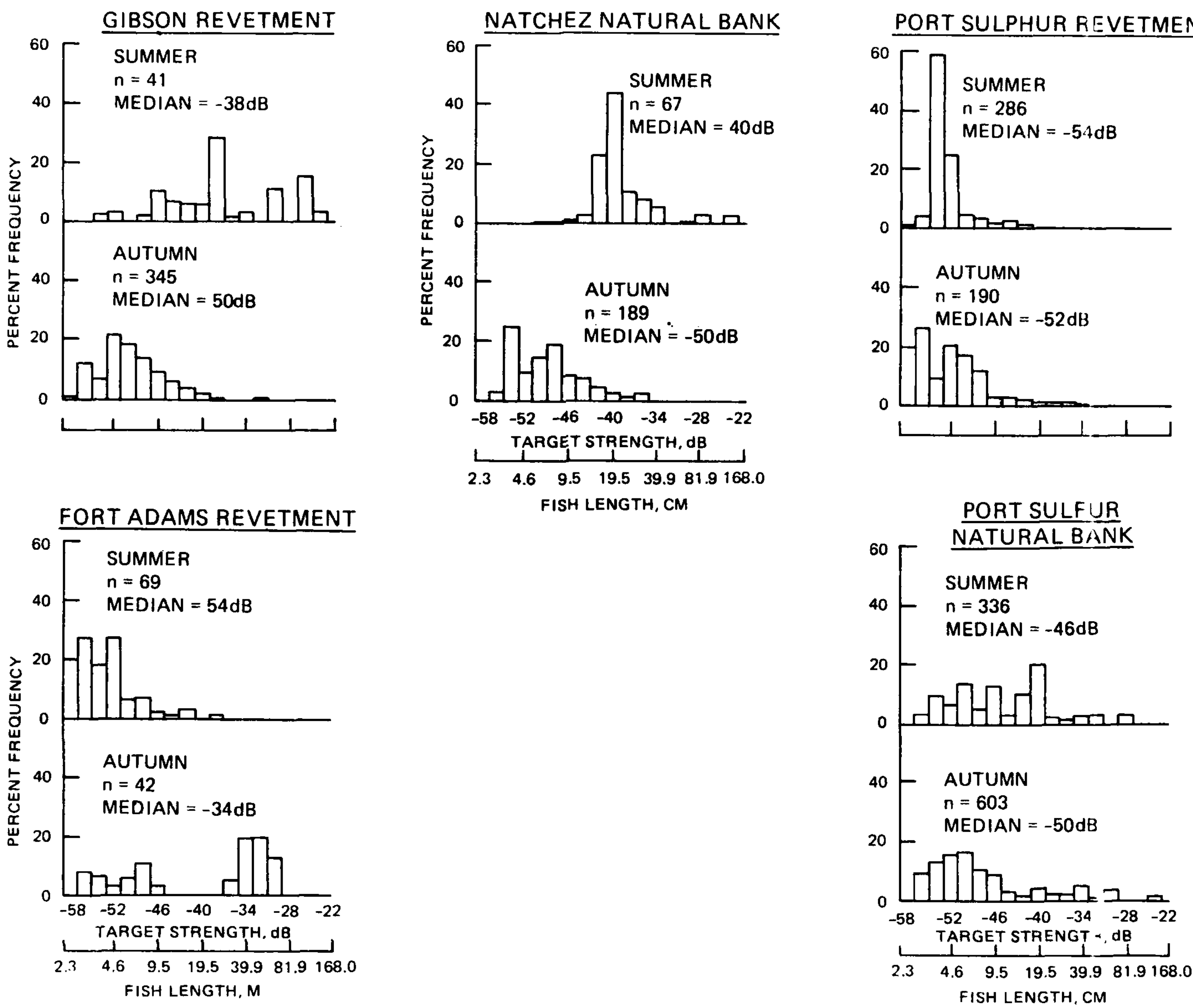

Figure 8. Horizontal distribution of acoustic targets along three revetted and two natural banks in the Lower Mississippi River during 1985

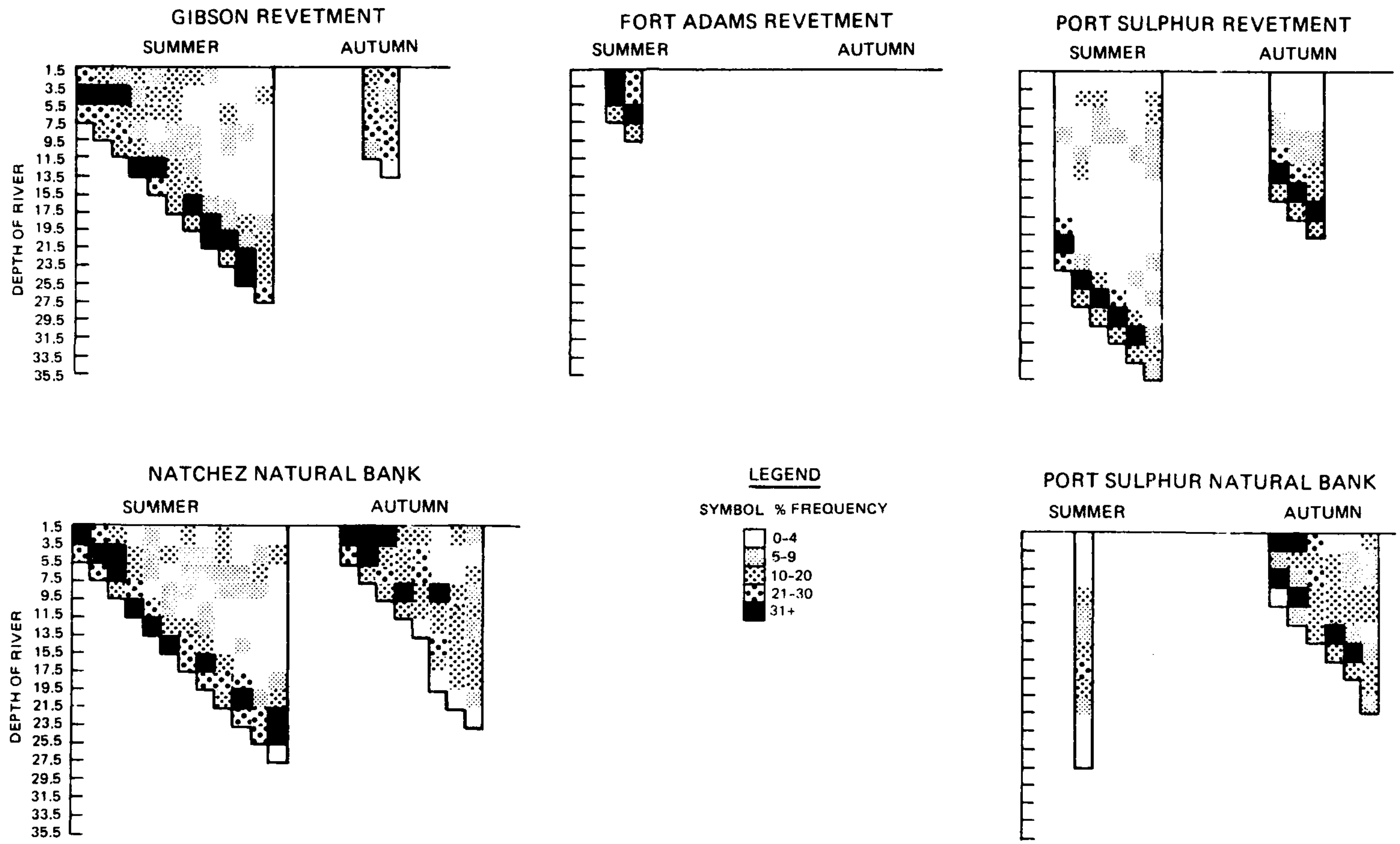

Figure 9. Vertical distribution of acoustic targets along three revetted and two natural banks in the Lower Mississippi River during 1985

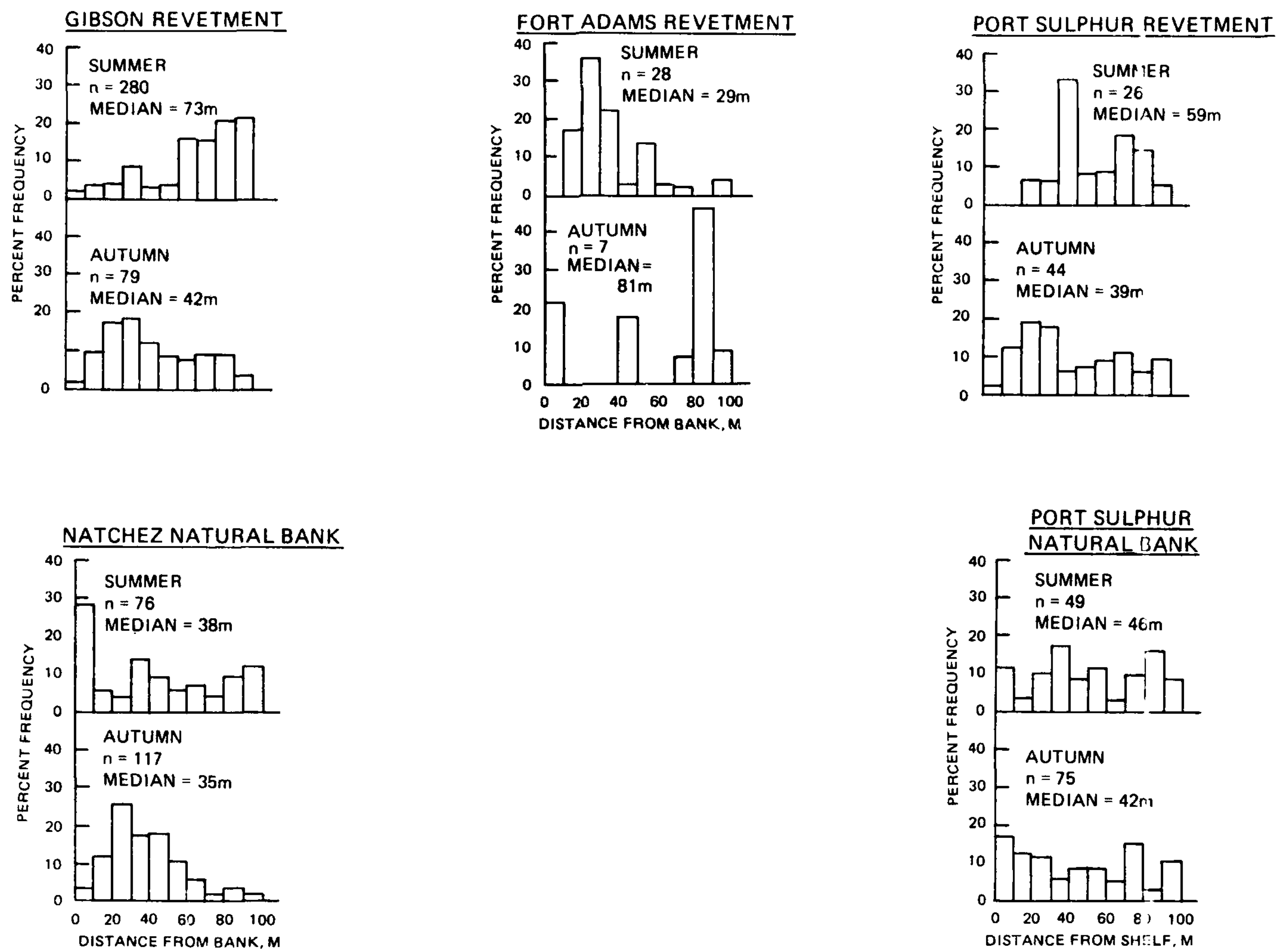

Figure 10. Distribution of target strengths, and their corresponding estimated fish sizes, for three revetted and two natural banks in the Lower Mississippi River during 1985

Table 10

Statistical Comparison of Mean Fish Density Among Banks and Seasons for Hydroacoustic Survey Data

Comparison	Difference† (Number of/ ha)	df	F††
Overall ANOVA			
Banks	--	4	18.3**
Seasons	--	1	3.7^{ns}
Banks x Seasons	--	4	4.2**
Error	--	286	--
Revetment vs Natural Bank			
At Natchez, summer	289	1	7.9**
At Natchez, fall	-365	1	1.4^{ns}
At Port Sulphur, summer	-150	1	1.7^{ns}
At Port Sulphur, fall	-112	1	3.5^{ns}
Summer vs Fall			
At Gibson Revetment	592	1	15.6**
At Natchez Natural Bank	-62	1	0.3^{ns}
At Fort Adams Revetment	73	1	9.2**
At Port Sulphur Revetment	-32	1	0.3^{ns}
At Port Sulphur Natural Bank	6	1	0.3^{ns}
Geographic Locations			
Revetted banks, summer	--	2	30.4**
Revetted banks, fall	--	2	15.0**
Natchez vs Port Sulphur natural bank, summer	279	1	0.1^{ns}
Natchez vs Port Sulphur natural bank, fall	347	1	0.2^{ns}

† Where presented, this is the difference in mean density of the first minus the second bank given under comparison.
†† * = 0.05 > P > 0.01; ** = P < 0.01; ns = not significant.

drum comprised almost all of the hoop net catch in both seasons. For this gear, C/f was very low at both times while C/y was relatively high in summer but declined considerably in fall (Table 8). Gizzard shad, threadfin shad, and striped mullet dominated boat electroshocker samples in summer, while gizzard shad and blue catfish comprised most of the catch in fall, when both C/f and C/y increased nearly two-fold.

66. The seine and backpack electroshocker collected a total of 23 species of small, near-shore fishes (Table A3), 22 in the summer and only 11 in the

fall. Nearly 95 percent of the 203 fish were taken with the seine, and no species was unique to the backpack electroshocker. Threadfin shad, silver chub, inland silverside, and white bass comprised most of the summer catch, and threadfin shad, emerald and silverband shiners, and inland silverside were the most abundant species in fall (Table A3). Overall C/f of these small fishes declined considerably in fall (Table 8), although the total catch with the backpack electroshocker increased from only a single fish in summer to 10 fish in fall. Seine C/y remained nearly constant between samplings, and backpack electroshocker C/y increased considerably.

67. Natchez Natural Bank supported a mean density of 483 ± 329 fish per hectare in summer (Table 9). Almost 30 percent of the fish occurred within 10 m of the shore; the remaining fish were evenly distributed from 10 to 100 m (Figure 8). Vertical distribution of fishes in the water column was divisible into three patterns associated with different distances from shore, and correspondingly, different bottom depths (Figure 9). In shallow waters to 9 m deep, fish occurred at all levels in the water column. At intermediate bottom depths, from 10 to 21 m, fish were found at all positions in the column, but with a large fraction occurring near the bottom. In deep areas (bottom depths from 22 to 27 m), more fish occurred near the bottom, secondary concentrations occurred 5 to 9 m deep, and few fish were found elsewhere in the water column. Target strengths from 67 recorded echo returns varied from -50 db to -24 db (6 to 132 cm) with a median size of -40 db (19 cm). Nearly 9 percent of echoes were between -44 db and -36 db (12 to 31 cm) in size (Figure 10).

68. In fall, the density of fish was 545 ± 507 per hectare (Table 9). While this was similar to the density of fish in summer, spatial distribution of fish both laterally from shore and vertically in the water column was quite different. In fall, few fish occurred within 10 m of shore, but numbers increased rapidly to 30 m, remained high to 50 m, and then declined rapidly at longer distances out to 100 m (Figure 8). More than 85 percent of fish were located from 10 to 60 m from shore, and median distance from shore was 35 m. Fish were vertically distributed somewhat evenly throughout the water column, and unlike during summer, did not show a marked preference for the bottom (Figure 9). Target strengths varied from -56 db to -36 db (3 to 31 cm), and median size of 189 echo returns was -50 db (6 cm) (Figure 10).

69. <u>Fort Adams Revetment.</u> Nearly 600 fish, representing 30 species, were captured from Fort Adams Revetment during the two sampling efforts

(Tables 6 and 7). Twenty-five species and 379 fish were collected in summer, and 19 species and 213 fish were taken in fall. The total weight of fish collected, in contrast to numbers, increased nearly two-fold in fall. In summer, hoop nets and the boat electroshocker captured 160 fish in 13 species; only 10 fish and three species were represented in hoop net collections, while 150 fish and 13 species were taken in boat electroshocker samples (Table A4). During the fall sampling the total number of fish and the number of species collected with these two gears remained relatively unchanged, as did the weight of fish captured in hoop nets; weight of fish taken by boat electroshocker increased considerably, however. Flathead catfish and freshwater drum dominated summer hoop net catches, while only flathead catfish was abundant in fall. In contrast, a number of species were abundant in boat electroshocker samples, including gizzard shad, skipjack herring, flathead catfish, white bass, and striped mullet in the summer, and gizzard shad, threadfin shad, common carp, blue catfish, flathead catfish, white bass, and striped mullet in the fall.

70. Seine and backpack electroshocker samples yielded 14 species and 219 fish in summer and 11 species and only 37 fish in the fall (Table A4). Nearly 93 percent of the fish were taken with seines; however, the total weight collected was higher for the backpack electroshocker in both samples due to the capture of a few large fish. Threadfin shad and inland silverside comprised over 80 percent of the catch in summer, and gizzard shad and inland silverside dominated the catches in fall. In October the C/f decreased for seining while the C/f for backpack electroshocker, and the C/y for both gears increased several-fold (Table 8).

71. Targets numbering 1 to 3 per transect were recorded on 18 of 42 perpendicular hydroacoustic transects in summer at Fort Adams Revetment. Estimated density on the revetted bank was 94 ± 22 fish per hectare (Table 9). Approximately 75 percent of the fish occurred 10 to 40 m from shore (Figure 8), with a median distance from shore of 24 m. Fish were vertically distributed rather evenly through the water column (Figure 9). Target strengths ranged from -58 db to -32 db (2 to 51 cm) with a median of -54 db (4 cm) in size (Figure 10).

72. In the fall survey, 1 to 2 targets per transect were detected, and fish were detected on only 5 of 42 transects. The resulting estimate of fish density was a low 21 ± 5 per hectare (Table 9). Fall fish density was

significantly lower (78 percent reduction) than that in the summer survey (Table 10). Due to the low numbers of fish detected, neither orientation from shore nor vertical distribution could be reliably determined. Target strengths from 42 echo returns ranged from -56 db to -30 db (3 to 64 cm) in size (Figure 10). Target strengths were separable into two distinct size classes representing small and large fish. About 40 percent of echo returns were from -56 db to -46 db (3 to 9 cm), and approximately 60 percent of returns measured -36 db to -30 db (31 to 64 cm).

73. Port Sulfur Revetment. A total of 523 fish, representing 19 species, were captured at this site during the two sampling efforts (Tables 6 and 7). Fourteen species and 347 fish were collected in the summer, and 12 species and 176 fish were taken in fall. Hoop nets took 18 fish of 5 species in June, although only freshwater drum was abundant (Table A5). Fall hoop net catches were lower for both C/f and C/y (Table 8), and no species dominated. Boat electroshocker catch declined substantially between sampling dates, both in terms of numbers and weight, and also in terms of the number of species collected. Striped mullet comprised over 87 percent of the numbers at both times, and over 82 percent of the weight.

74. Use of the seine at this site was precluded by the roughness of the revetment. Backpack electroshocker samples yielded 17 fish and 3 species in summer, with striped mullet dominating the catch. No fish were taken with this gear in fall (Table A5).

75. Along Port Sulphur Revetment targets numbering from 1 to 6 per transect were detected on 9 of 17 perpendicular transects sampled during summer. Mean density of fish from this data was estimated at 54 ± 33 per hectare of surface area (Table 9). Position measurements from 26 targets showed no fish within 20 m of shore, few fish from 20 to 40 m, about 30 percent of fish from 40 to 50 m, and 60 percent of fish from 50 to 100 m (Figure 8). Median distance was 59 m from shore. Vertically, fish were strongly oriented toward the bottom, with occasional small concentrations near the surface or mid-depth (Figure 9). Target strengths from 286 echo returns ranged from -58 db to -42 db (2 to 15 cm) with a median strength of -54 db (4 cm) (Figure 10).

76. Mean density of fish in fall on the Port Sulphur Revetment was 86 ± 37 per hectare (Table 9) and was not significantly different from the summer density (Table 10). Fish were distributed roughly uniformly from shore to 100 m, except that few fish were present within 10 m of shore (Figure 8).

Nearly all fish occurred in the lower half of the water column, and they appeared to be mostly bottom oriented, as they were in summer (Figure 9). Target strengths of 190 echo returns varied from -58 db to -30 db (2 to 64 cm) with a median size, -52 db (5 cm), about the same as in summer (Figure 10).

77. Port Sulfur Natural Bank. Twenty-three species and 401 fish were collected from this site, 18 species and 166 fish in summer, and 11 species and 235 fish in fall (Table 6 and 7). The total weight of fish captured decreased somewhat in fall, however. Summer hoop net and boat electroshocker catches consisted of 53 fish in 10 species, with hoop nets accounting for about two-thirds of the total (Table A6). Atlantic stingray and freshwater drum comprised most of the hoop net catches, while striped mullet was the only species abundant in boat electroshocker collections. Hoop net C/f and C/y declined dramatically in fall (Table 8); freshwater drum was the only species even moderately abundant at that time. Boat electroshocker C/f and C/y, however, greatly increased, with almost all the increase attributable to the large catch of striped mullet.

78. Seine and backpack electroshocker samples produced 13 species and 113 fish in the summer, and 140 fish, but only three species, in the fall (Table A6). Overall, seining accounted for more than 98 percent of the fishes taken, with bay anchovy dominating (92 percent). Several adult fish collected with the backpack shocker accounted for most of the weight, however.

79. Mean fish density associated with the natural bank at Port Sulphur was 206 ± 163 per hectare in summer (Table 9). Fish were equally abundant from the shelf dropoff out to the sampling distance of 100 m from the shelf edge (Figure 8). Vertically, fish were predominantly positioned near the middle of the water column (Figure 9). Target size from 336 echo returns ranged from -56 db to -30 db (3 to 64 cm) with a median size of -46 db (9 cm) (Figure 10).

80. In the fall, mean fish density was 86 ± 37 per hectare (Table 9), significantly lower than in summer (Table 10). As in summer, fish were about equally abundant from the shelf edge to 100 m out into the channel (Figure 8). Fish showed a broader vertical distribution in the fall than in the summer, occurring everywhere from surface to bottom with no apparent depth preference (Figure 9). Target size distribution showed the same broad occurrence as in summer. Target strength ranged from -58 db to -24 db (2 to 132 cm) with a median size of -50 db (6 cm) (Figure 10).

81. Comparisons among banks. Statistical comparisons of mean fish densities from both traditional gears (Table 11) and hydroacoustics (Table 10) indicated differences among: (a) the five banks overall; (b) between the two natural banks and among the three revetted banks; (c) between the paired banks at Natchez and at Port Sulphur; and (d) between seasons. Traditional gear use also showed considerable differences in the fish assemblages among banks (Tables 6 and 7; Tables A2-A6), particularly between the combined Natchez-Fort Adams reaches and the Port Sulphur reach. Hydroacoustics also demonstrated among bank and between season differences in horizontal and vertical fish distributions.

82. Of the traditional gears, only boat electroshocking showed significant differences among the five banks overall (Table 11), with Fort Adams and Port Sulphur revetments having significantly higher catches than the remaining three banks in both seasons (Table 8). Hydroacoustics also indicated significant overall differences among banks (Table 10), but the ranking differed markedly from that of electroshocking. In summer, Gibson Revetment and the Natchez Natural Bank had high fish densities, Port Sulphur Natural Bank had an intermediate density, and Fort Adams and Port Sulphur revetments had low densities (Table 9). Rankings of banks by hydroacoustics remained similar in fall with the exception of the Gibson Revetment, at which densities declined greatly.

83. The C/f for boat electroshocking was significantly higher at the Natchez Natural Bank than at the Port Sulphur Natural Bank in the summer, and overall (Tables 8 and 11). No other gear suggested differences in catch rates among the two natural banks. Although the hydroacoustic surveys did not demonstrate statistically significant differences between these banks (Table 10), the estimated mean densities (Table 9) showed a relationship similar to that for electroshocking.

84. In contrast to the relative similarity displayed by the natural banks, the three revetted banks showed more variability. Boat electroshocker catches were significantly higher at Fort Adams and Port Sulphur than at Natchez in both seasons (Tables 8 and 11); in summer, catches at Port Sulphur were also significantly higher than at Fort Adams. Although the overall test for differences among revetted banks did not indicate significance for hoop net catches, the specific contrasts suggested that catches at Fort Sulphur were higher than at Fort Adams (Table 11). Hydroacoustic surveys showed that

Table 11

Results of Overall Analysis of Variance Tests and of Specific Linear Contrasts for Fish Catches from Five Banks on the Lower Mississippi River

Test or Contrast††	F-Value by Gear Type†							
	Boat Electroshocker		Hoop Nets		Backpack Electroshocker		Seines	
	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight
All Banks	23.40**	11.45**	1.71^{ns}	1.03^{ns}	0.92^{ns}	1.31^{ns}	0.09^{ns}	0.98^{ns}
Summer vs Fall	17.61**	17.38**	9.11**	8.59**	[illegible].64*	5.21*	12.04**	0.55^{ns}
Natchez: RV vs NB	0.03^{ns}	0.17^{ns}	0.01^{ns}	0.18^{ns}	0.53^{ns}	0.04^{ns}	0.27^{ns}	
Port Sulphur: RV vs NB	70.08**	21.95**	0.18^{ns}	0.03^{ns}	1.03^{ns}	0.26^{ns}		0.34^{ns}
Natural Banks	4.66*	0.08	0.63^{ns}	1.10^{ns}	0.18^{ns}	0.65^{ns}	0.13^{ns}	1.36^{ns}
Revetted Banks	19.08**	10.98**	2.32^{ns}	1.48^{ns}	0.35^{ns}	2.09^{ns}		
Gibson RV vs Fort Adams RV	17.18**	13.93**	0.97^{ns}	0.59^{ns}	0.25^{ns}	3.40^{ns}	0.02^{ns}	1.09^{ns}
Gibson RV vs Port Sulphur RV	37.13**	0.34^{ns}	1.37^{ns}	0.90^{ns}	0.09^{ns}	2.97^{ns}		
Fort Adams RV vs Port Sulphur RV	3.57*	19.37**	4.62*	2.94^{ns}	0.68^{ns}	0.02^{ns}		

† * = 0.05 > P > 0.01; ** = P< 0.01; ns = not significant.
†† RV = Revetted bank; NB = natural bank.

densities of fish along the Gibson Revetment were significantly higher than along Fort Adams or Port Sulphur Revetments in both seasons (Tables 9 and 10).

85. No statistically significant differences in either C/f or C/y were found between the natural and revetted banks at Natchez for any gear (Table 11). Nearly identical species lists were compiled for these two banks (Tables 6 and 7), and the relative abundances of most species showed general agreement. Only three species showed appreciable dissimilarities in their distributions: blue catfish were more numerous at the natural bank in the fall, while threadfin shad and white bass were more common along the revetted bank in the summer.

86. Boat electroshocker samples at Port Sulphur indicated significantly greater catches, both in terms of numbers and weights, along the revetted bank. Nearly all the difference in both sampling efforts was attributable to variation in the numbers of striped mullet captured (Tables 6 and 7 and Tables A5 and A6). Only three other species showed appreciable differences among the banks. Atlantic stingrays were taken only along the natural bank, and freshwater drum were more abundant there, while American eels were captured only on the revetted bank. These species were not sufficiently abundant, however, to permit strong conclusions concerning their distributions. No significant differences in C/f or C/y were found between the natural and revetted banks at Port Sulfur (Table 11) for either hoop nets or the backpack electroshocker. No comparison of seine catches was possible because samples could not be collected from the revetted bank.

87. Mean fish densities derived from hydroacoustics were generally different between revetted and natural banks, but there was no definitive overall trend (Table 9). At Natchez in the summer, mean density was significantly higher (Table 10) on the revetment (772 fish per ha) than on the natural bank (483 fish per ha). Conversely, at Natchez in the fall and at Port Sulphur in both the summer and fall, fish density was higher on the natural bank than on the revetted bank, although in no instance was the difference statistically significant ($0.06 < P < 0.24$).

88. Seasonal changes at the five banks were evident for both the traditional gears and hydroacoustics (Tables 8 and 9). Boat electroshocker C/f and C/y was significantly higher in the fall at all banks except the Port Sulphur Revetment, at which catches were significantly lower. Hoop net C/f and C/y both declined significantly overall in the fall; four of five banks showed

drops in hoop net catch, with Fort Adams Revetment remaining essentially unchanged. Seine catches declined significantly from summer to fall at all except Port Sulphur Natural Bank, at which catch rates were unchanged. Backpack electroshocker C/f and C/y also dropped significantly overall in the fall, but the changes for individual banks showed considerable variability.

89. Using hydroacoustics, the two natural banks showed no evidence of seasonal differences in abundance between summer and fall (Tables 9 and 10). However, two of the three revetted sites, Natchez and Fort Adams, had estimated fall fish densities that were significantly lower (>75 percent) than summer densities.

90. Target strength distributions (Figure 10) showed variation both seasonally and geographically. At Natchez, both the revetted and natural banks had larger targets in the summer than in the fall. In the summer, median target size was -40 db to -38 db (19 to 25 cm), with the largest targets reaching -22 db (168 cm). In fall, median target size was only -50 db (6 cm) and the largest target was -32 db (51 cm). Overall at Natchez, fish were fewer in number and smaller in size during fall. Fish size distribution at Port Sulphur was seasonally similar in the summer and the fall, and generally resembled the smaller fall size distribution at Natchez. Unlike at Natchez, there was some difference between size distributions at the natural and revetted banks, with the larger targets associating with the natural bank at Port Sulphur. Fish size distributions were generally unimodal, with large numbers of smaller fish and progressively smaller numbers of larger fish. The single exception to this pattern was at Fort Adams Revetment during fall, where a bimodal distribution of sizes grouped roughly into small (3-9 cm) and large size classes (31-64 cm) was observed.

91. Vertical target distributions (Figure 9) showed that fish were moderately to markedly bottom oriented at three of four study banks during at least one season of the year. At the Port Sulphur Revetment, fish were mostly bottom dwelling during both seasons. At both Gibson Revetment and Natchez Natural Bank, fish were bottom oriented during summer, but they were more evenly distributed in the water column during fall. At these three banks fish occurred throughout the water column in shallower waters nearer the shore and were bottom oriented only in deeper water farther from shore. In contrast, fish associated with the natural bank at Port Sulphur did not show any bottom orienting tendency during either summer or fall. Fish at this bank were

positioned toward the middle of the water column in the summer and irregularly throughout the column in the fall. The Fort Adams Revetment did not have an adequate number of targets to fully investigate the vertical distribution.

Food Habits

92. Relatively few specimens of target species were taken in which food was present. Only two small channel catfish having food items in their stomachs were taken from Gibson Revetment overall, and only one channel catfish was taken from Port Sulphur Revetment in the fall. Fort Adams Revetment summer and fall samples contained moderate numbers of blue and flathead catfishes. Blue catfish fed on a wide variety of foods (Figure 11), while flathead catfish ate almost entirely fish and shrimp. Natchez Natural Bank yielded low numbers of all three catfish species. Fish formed most of the diet of channel and blue catfishes, while the single flathead had only shrimp in its stomach (Figure 11).

Macroinvertebrates

93. Gibson Revetment. Comparisons of ACM (slab and Hess samples) and snag macroinvertebrate assemblages among banks are complicated by differences in actual sampling dates for the second sampling effort. A rapid rise in river stage in fall (October) prevented ACM slab, Hess, and snag samples from being collected in the Natchez and Fort Adams reaches. The ACM slab, Hess, and snag samples in these two reaches were not collected until January 1986, when winter conditions prevailed. All samples were collected at Port Sulphur, however, as scheduled. Thus, any differences noted among banks in the following section are confounded by a seasonal effect, the magnitude of which is unknown.

94. Fourteen taxa of macroinvertebrates were identified from samples of the sediments overlaying the Gibson Revetment in the summer (Table 12). Summer densities were relatively high, averaging over 10,000 organisms per square metre. A much more diverse assemblage, 37 taxa, was collected in fall (Table 13); and estimated densities were nearly 3 times those of summer. Oligochaetes dominated the benthos of the sediments in both summer and fall (Table B1 and B4). Tubificid immatures without capilliform chaetae, and adult *Limnodrilus maumeensis*, were the most common taxa identified in summer. In fall, chironomids, primarily *Rheotanytarsus* spp., were also found in relatively high numbers.

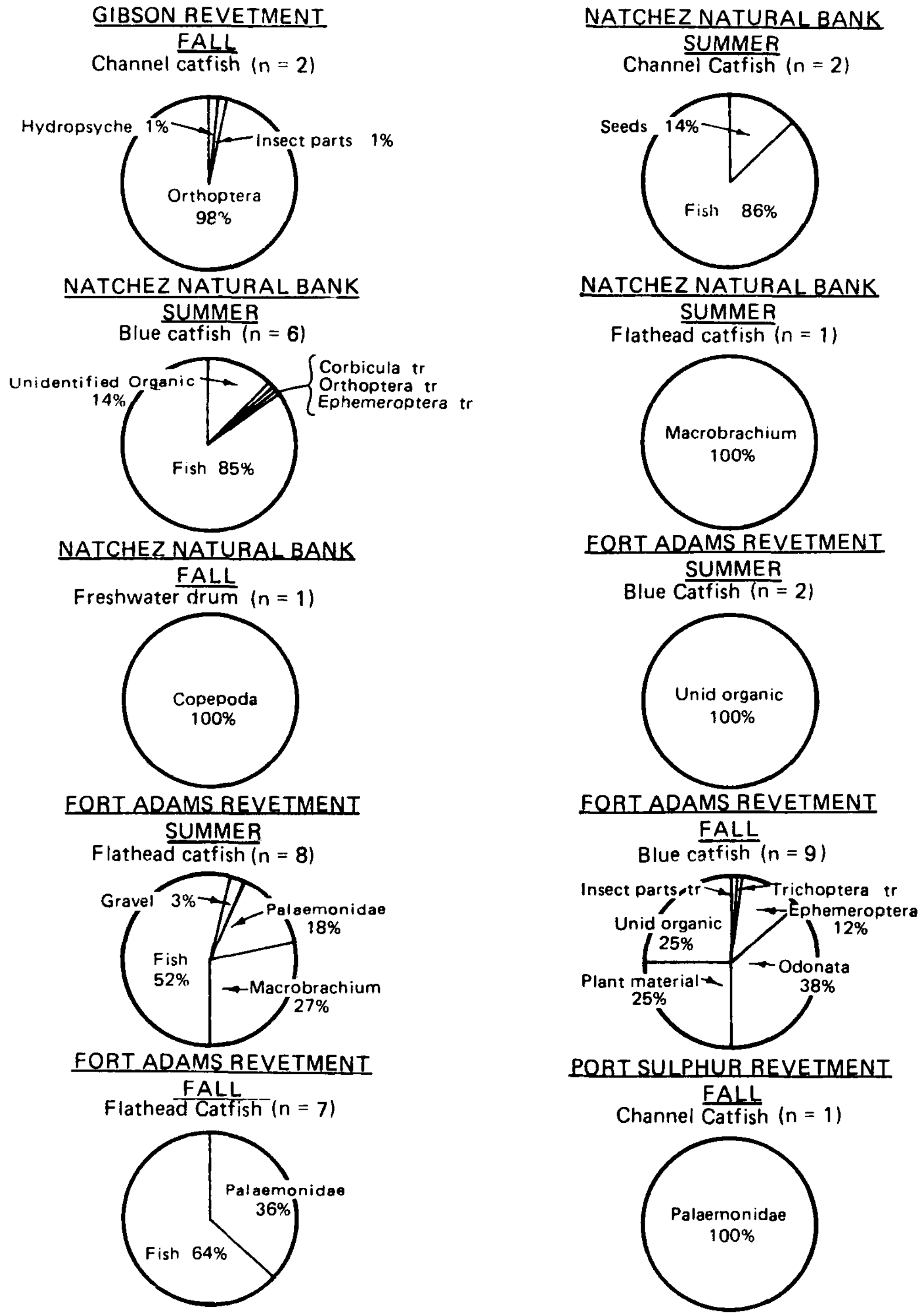

Figure 11. Composition of the diet, by weight, of selected fish species collected along three revetted and two natural banks in the Lower Mississippi River during 1985. Numbers indicate the total number of fish of each species which contained food items at each time

Table 12

Number of Taxa, Mean Density, Mean Biomass, and Dominant Taxa of Macroinvertebrates by Gear Type for Five Banks on the Lower Mississippi River, Summer 1985*

Gibson Revetment		Natchez Natural Bank		Fort Adams Revetment		Port Sulphur Revetment		Port Sulphur Natural Bank	
				Shipek Grab					
Oligochaeta	95%	Ephemeroptera	58%	Chironomidae	24%	Oligochaeta	79%	Ephemeroptera	64%
Tubificidae (nc)	63%**	*T. incertus*	58%	*C. orbicus*	20%	Tubificidae (nc)	61%	*T. incertus*	58%
L. maumeensis	26%	Chironomidae	18%	Turbellaria	20%	Chironomidae	11%	Oligochaeta	13%
		C. orbicus	15%	*Dugesia*	20%	*H. curtilamellata*	7%	Chironomidae	9%
N = 13		Pelecypoda	11%	Gastropoda	16%			*Cryptochironomus*	9%
D = 10,558		*Corbicula*	6%	Ephemeroptera	12%	N = 12 D = 678		Amphipoda	9%
		Trichoptera	7%	Oligochaeta	8%			*Gammarus*	9%
				Trichoptera	8%				
		N = 11 D = 5,704		N = 11 D = 607				N = 7 D = 1,675	
				Hess Sampler					
Trichoptera	96%					Amphipoda	80%		
H. orris	66%			Gastropoda	100%	*Gammarus*	80%		
Hydropsychidae	28%					Ephemeroptera	13%		

(Continued)

* Density is in numbers per m^2, except for drift samples, for which the units are numbers per 100 m^3. Biomass is milligram per square metre.

** (c) = tubificid immatures with capilliform chaetae; (nc) = tubificid immatures lacking such chaetae. Second taxon was a colonial organism for which counts cannot be accurately made.

(Sheet 1 of 4)

Table 12 (Continued)

Gibson Revetment	Natchez Natural Bank	Fort Adams Revetment	Port Sulphur Revetment	Port Sulphur Natural Bank
N = 18 D = 9,775		N = 2† D = 47	Pentagenia 7% S. integrum 7% Copepoda 7% N = 4 D = 177	
		ACM Slabs		
Trichoptera 97% H. orris 53% Hydropsychidae 44% N = 19 D = 2,023 B = 301		Ephemeroptera 54% S. integrum 46% Trichoptera 21% H. orris 13% Gastropoda 8% N = 15 D = 61 B = 25	Gammarus 52% Oligochaeta 27% Tubificidae (nc) 20% Helobdella 7% N = 12 D = 97 B = 24	
		Snags		
	Trichoptera 85% H. orris 50% Hydropsychidae 35% Chironomidae 14%			Chironomidae 79% D. nervosus I 27% Stenochironomus 15% P. scalaenum 10%

(Continued)

(Sheet 2 of 4)

Table 12 (Continued)

Gibson Revetment	Natchez Natural Bank	Fort Adams Revetment	Port Sulphur Revetment	Port Sulphur Natural Bank
				Oligochaeta 10%
	N = 25			N = 20
	D = 2,213			D = 96
	B = 588			B = 12
		Core Samples Under ACM		
			Amphipoda 50%	
			Gammarus 33%	
			Crangonyx 17%	
			Chironomidae 23%	
			Isopoda 11%	
			Lirceus 11%	
			Oligochaeta 17%	
			Tubificidae (c) 6%	
			Naididae 11%	
			Nais elinguis 11%	
			N = 9	
			D = 360	

(Continued)

(Sheet 3 of 4)

Table 12 (Concluded)

Gibson Revetment	Natchez Natural Bank	Fort Adams Revetment	Port Sulphur Revetment	Port Sulphur Natural Bank
		Drift		
Culicidae 34%				
Chaoborus 34%			Copepoda 35%	
Mysidae 21%			Oligochaeta 23%	
Taphromysis 21%			Tubificidae (nc) 23%	
Copepoda 8%			Ephemeroptera 9%	
			Pentagenia 9%	
N = 28			N = 10	
D = 47			D = 13	

(Sheet 4 of 4)

Table 13

Number of Taxa, Mean Density, Mean Biomass, and Dominant Taxa of Macroinvertebrates by Gear Type for Five Banks on the Lower Mississippi River, Fall 1985*

Gibson Revetment		Natchez Natural Bank		Fort Adams Revetment		Port Sulphur Revetment		Port Sulphur Natural Bank	
				Shipek Grab					
Oligochaeta	68%	Oligochaeta	46%	Oligochaeta	66%	Oligochaeta	42%	Oligochaeta	59%
Tubificidae (nc)	49%**	Tubificidae (nc)	34%	Tubificidae (nc)	51%	*A. piquetti*	28%	Tubificidae (nc)	52%
L. maumeensis	15%	Chironomidae	29%	*L. maumeensis*	10%	Nematoda	28%	Chironomidae	12%
Chironomidae	25%	*C. orbicus*	10%	Chironomidae	25%	Pelecypoda	21%	Nematoda	12%
Rheotanytarsus	22%	Pelecypoda	14%	*Rheotanytarsus*	20%			Copepoda	7%
N = 37		N = 22		N = 29		N = 11		N = 27	
D = 30,461		D = 2,985		D = 18,204		D = 2,476		D = 9,248	
				Hess Sampler					
Trichoptera	40%			Copepoda	38%	Chironomidae	63%		
H. Orris	26%			Amphipoda	23%	*Dicrotendipes*	20%		
Chironomidae	38%			*Corophium*	23%	*D. nervosus* I	20%		
Rheotanytarsus	19%			Chironomidae	15%	Oligochaeta	35%		

(Continued)

* Density is in numbers per m^2, except for drift samples, for which the units are numbers per 100 m^3. Biomass is milligram per square metre.

** (c) = tubificid immatures with capilliform chaetae; (nc) = tubificid immatures lacking such chaetae.

(Sheet 1 of 3)

Table 13 (Continued)

Gibson Revetment		Natchez Natural Bank		Fort Adams Revetment		Port Sulphur Revetment		Port Sulphur Natural Bank	
Cricotopus	12%			Trichoptera	13%	*N. pardalis*	35%		
				Hydropsychidae	11%				
N = 27				Ephemeroptera	4%	N = 22			
D = 1,329				N = 12		D = 14,377			
				D = 553					
ACM Slabs									
Trichoptera	47%			Ephemeroptera	32%	Chironomidae	75%		
H. orris	24%			*S. integrum*	32%	*Dicrotendipes*	50%		
Hydropsychidae	18%			Trichoptera	29%	*Cricotopus*	11%		
Chironomidae	35%			*H. orris*	19%	Oligochaeta	23%		
Ephemeroptera	15%			Chironomidae	21%	*N. pardalis*	19%		
S. integrum	14%			Amphipoda	14%				
N = 25				*Corophium*	12%	N = 16			
D = 87				N = 26		D = 1,952			
B = 209				D = 323		B = 73			
				B = 147					
Snags									
		Trichoptera	97%					Chironomidae	93%
		H. orris	81%					*Dicrotendipes*	69%
		Hydropsychidae	16%					*Cricotopus* sp.	11%

(Continued)

(Sheet 2 of 3)

Table 13 (Concluded)

Gibson Revetment	Natchez Natural Bank	Fort Adams Revetment	Port Sulphur Revetment	Port Sulphur Natural Bank
				C. intersectus 8%
				Oligochaeta 7%
	N = 17 D = 1,562 B = 3,176			N = 22 D = 8,614 B = 212
		Core Samples Under ACM		
Oligochaeta 86%		Amphipoda 43%		Amphipoda 55%
Tubificidae (nc) 79%		*Corophium* 43%		*Corophium* 29%
				Gammarus 13%
				Crangonyx 13%
				Oligochaeta 23%
				Tubificidae (nc) 16%
N = 4 D = 280		N = 5 D = 140		N = 12 D = 620
		Drift		
Chironomidae 52%				Copepoda 96%
pupae 45%				N = 8
Cladocera 24%				D = 250
Daphnia 24%				
Copepoda 16%				
N = 29 D = 124				

(Sheet 3 of 3)

95. The macroinvertebrate assemblage found on the clean ACM (Hess and ACM slab samples) at the Gibson Revetment consisted of 29 taxa in summer (Table 12), 18 identified from Hess samples and 19 from the ACM slabs (Table B1). Estimated densities derived from these two sampling methods averaged 9,777 and 2,023 organisms per square metre of revetment, respectively. Biomass estimated from ACM slab samples averaged 301 mg per m^2. Fall samples (Table 13) contained a few more taxa overall, but estimated densities and biomass estimates were considerably lower than in summer. Trichopterans, principally *Hydropsyche orris*, dominated the macroinvertebrate numbers in summer (Tables 12 and B1), and they were also the most abundant group in fall (Tables 13 and B4). In fall, however, both chironomids (*Rheotanytarsus* spp. and *Cricotopus* spp.) and mayflies (primarily *Stenonema* spp.) were also common.

96. Summer drift samples collected along the Gibson Revetment yielded 28 taxa (Tables 12 and B1), but low densities. *Chaoborus* spp., the mysid shrimp *Taphromysis louisianae*, and copepods were the dominant taxa collected. Similar number of taxa were found in fall drift samples, but estimated density was nearly 3 times higher than in summer (Tables 13 and B4), however chironomid pupae, *Daphia* spp., and copepods comprised most of the drift at this time.

97. Sediment samples taken from under the ACM (listed as "Core" in the tables) at Gibson Revetment in summer were inadvertently processed for grain-size distribution; therefore, no information for this site is available. In fall, core samples contained only four taxa overall, with an estimated density of only 280 organisms per square metre (Tables 13 and B4). Immature tubificids without capilliform chaetae were the dominant taxon.

98. *Natchez Natural Bank*. The mayfly *Tortopus incertus* was the most numerous of the 11 macroinvertebrate taxa identified from the Natchez Natural Bank sediment samples in summer (Tables 12 and B1). However, chironomids, caddisflies, and *Corbicula fluminea* were also found in relatively high numbers. Mean density was only about one-half that of the nearby revetted bank. In fall, tubificid oligochaetes, chironomids, and pelecypods were dominant among the 22 identified taxa (Tables 13 and B4). Mean density was slightly more than 3,000 organisms per square metre, lower than in summer.

99. Snag samples were dominated by caddisflies and chironomids in summer (Tables 12 and B1), and by caddisflies in fall (Table 13 and B4). *H. orris* was the most abundant species in both sampling periods. Both number of taxa identified and density of organisms were lower in fall than in summer.

Estimated biomass per square metre of snag surface, however, increased considerably, from 588 mg to 3,126 mg.

100. Fort Adams Revetment. Eleven taxa, and an estimated 607 organisms per square metre, were collected from the sediments overlaying this revetted bank during the summer sampling (Tables 12 and B2). Six taxa each comprised at least 8 percent of the total numbers. Nearly 3 times as many taxa, and 30 times the density, were taken in fall, although only two invertebrate groups, tubificids and chironomids, were present in appreciable numbers (Tables 13 and B5). The dominant chironomid species was different during the two seasons; *Chernovskiia orbicus* was most common in summer, while *Rheotanytarsus* spp. was most abundant in the fall.

101. Clean ACM samples were characterized by mayflies, caddisflies, and gastropods in summer; the larger, ACM slab samples had the most diverse invertebrate assemblage, while only gastropods were taken in the Hess samples (Tables 12 and B2). Sixteen taxa were taken overall, with an estimated density and biomass of 61 organisms and 25 mg per m^2 of revetment surface. In fall, the revetment was colonized by a more diverse and varied invertebrate assemblage. A total of 29 taxa were collected overall, 12 with the Hess samplers and 26 from the ACM slabs (Tables 13 and B5). Chironomids, caddisflies, mayflies, and the amphipod *Corophium* sp. were all commonly collected with both sampling methods. Copepods were taken almost exclusively with the Hess sampler. Both density and estimated biomass per square metre were considerably higher than in the summer on this revetment.

102. Core samples from under the ACM were collected in fall to allow comparisons with the other two revetments. Only five taxa were collected overall, with the amphipod *Corophium* sp. and tubificid oligochaetes being the dominant taxa collected. Estimated density was 140 organisms per square metre (Tables 13 and B5). Drift samples were not collected at this site.

103. Port Sulphur Revetment. Twelve taxa, present at an estimated density of 680 organisms per square metre, were taken from the sediments overlaying Port Sulphur Revetment during the summer sampling (Tables 12 and B3). In fall, a similar number of taxa were collected, but the estimated density was considerably higher, 2,476 organisms per square metre (Tables 13 and B6). Oligochaetes were the dominant taxon in both seasons; in the summer both nematodes and pelecypods were also common, and in the fall chironomids comprised an appreciable percentage. The most common oligochaete taxon was

immature worms without capilliform chaetae; the most abundant chironomid species was Harnisha curtilamellata.

104. Four and 12 taxa were collected from the ACM by the Hess sampler and ACM slab methods, respectively, in summer (Tables 12 and B3). The amphipod Gammarus sp. was the dominant organism collected by both methods; mayflies and copepods were also common in Hess samples, while tubificids and leeches (Helobdella sp.) were relatively abundant on the ACM slabs. Estimated densities from Hess and ACM slab samples were low (177 and 97 organisms per square metre, respectively), and the estimated biomass was also quite low, only 24 mg per m^2. Fall densities were considerably higher for both collecting methods (Tables 13 and B6), and the biomass was nearly 3 times higher. The taxonomic composition also changed dramatically, with chironomids and oligochaetes comprising almost all of the numbers. The most common chironomids were Dicrotendipes sp., D. nervosus I, and Cricotopus sp.; all of the oligochaetes were mature worms, and they were represented almost exclusively by N. pardalis.

105. Summer drift along Port Sulphur Revetment consisted of 11 taxa (Tables 12 and B3), with copepods, immature Tubificidae without capilliform chaetae, and the burrowing mayfly Pentagenia vittigera being most common. Estimated density of the invertebrate drift was very low, only 13 organisms per 100 m^3. Although fewer taxa were found in the fall drift samples, density was nearly 20 times as high as in summer (Tables 13 and B6). Copepods were the dominant taxon again, this time comprising over 95 percent of the organisms collected.

106. Nine taxa, with an estimated density of 360 organisms per square metres, were identified from core samples taken from under the ACM in summer (Tables 12 and B3). The amphipods Gammarus sp. and Crangonyx sp., the isopod Lirceus sp., and the naidid oligochaete Nais elinguis were all common. In fall core samples (Tables 13 and B6), three amphipod genera were common, as were immature tubificids. Twelve taxa were identified overall, with the estimated density being 620 organisms per square metre.

107. Port Sulphur Natural Bank. Seven taxa of macroinvertebrates were identified from sediment samples from this natural bank in summer (Tables 12 and B3). Mean density was moderately high, however, 1,675 organisms per square metre. The burrowing mayfly T. incertus was the dominant organism, and oligochaetes, chironomids, and the amphipod Gammarus sp. were also relatively

abundant. In the fall, both the number of taxa and the mean density of organisms were much higher (Tables 13 and B6). The taxonomic composition of the benthos was also quite different, with tubificid oligochaetes, chironomids, nematodes, and copepods being most abundant.

108. Snag samples were dominated by chironomids in summer, with three species (*Dicrotendipes nervosus* I, *Stenochironomus* sp., and *Paratendipes scalaenum*) being relatively common (Tables 12 and B3). A total of 19 taxa were collected from the snags; mean density was 96 organisms per square metre, and estimated biomass was only 12 mg per m^2. As was found for sediment samples, the number of taxa, the mean density, and the estimated biomass per square metre were higher on snags in the fall than in the summer (Tables 12 and B6). The major taxa remained chironomids and oligochaetes; however, two of the three common chironomid species were different from the species found in summer (*Orthocladius* sp. and *Cricotopus* sp.).

109. Comparisons Among Banks. In summer, the sediments of the five banks supported somewhat different macroinvertebrate assemblages (Table 12). The number of taxa identified was similar at four of the banks, but was lower at Port Sulphur Natural Bank. Densities exhibited a considerable range, but they were several times higher at the two Natchez reach banks than elsewhere.

110. The natural bank faunas were relatively similar, being dominated by *T. incertus*, and to a lesser extent, chironomids. The dominant chironomid species differed between the two sites, however, *C. orbicus* dominating at Natchez and *Cryptochironomus* sp. at Port Sulphur. Also, *Corbicula Fluminea* and caddisflies were moderately common at Natchez, while *Gammarus* sp. and oligochaetes were the most abundant of the remaining taxa at Port Sulphur. The macroinvertebrate faunas of the revetment sediments showed little similarity to those of the natural banks, and they also differed considerably among themselves. Oligochaetes comprised most of the numbers at Gibson Revetment, and oligochaetes and chironomids dominated at Port Sulphur Revetment. The Fort Adams Revetment sediments, in contrast, were inhabited by a variety of relatively common invertebrates, with oligochaetes being only a minor part.

111. The number of taxa collected from the sediments in fall increased by nearly 2 to 4 times at all banks except the Port Sulphur Revetment, where the number remained about the same. Densities also increased greatly except at one bank, the natural bank at Natchez. Oligochaetes, chironomids, pelecypods, and nematodes were the dominant invertebrates collected at the five

banks (Table 13). Nematodes, however, were collected commonly only in Port Sulphur samples, while pelecypods occurred in abundance only at Port Sulphur Revetment and Natchez Natural Bank. In addition, the dominant species of oligochaetes and chironomids differed among sites where these taxa were common.

112. Hard, relatively clean substrates, represented by snags on the natural banks and by the ACM on the revetted banks, yielded considerably different density and biomass estimates in summer. Density and biomass were both highest at the two Natchez banks, with estimates from snags being higher. The five banks were also colonized by relatively unique faunas to a large degree (Table 12). Both ACM and snag samples in the Natchez reach were dominated by caddisflies, though the natural bank snag samples also had a relatively high number of chironomids. Port Sulphur Revetment and Natural Bank samples, on the other hand, yielded quite different faunas. The amphipod *Gammarus* sp., along with oligochaetes and mayflies, comprised most of the revetment fauna, while chironomids and oligochaetes were the most numerous taxa found on the snags. The Fort Adams Revetment samples were different still, being dominated by mayflies, caddisflies, and gastropods.

113. Generally more taxa were collected from the snags and ACM in the fall and winter (Table 13) than in the summer. Both density and biomass increased substantially at Fort Adams (summer to winter) and Port Sulphur (summer to fall). Density decreased, however, at both Natchez banks; biomass also decreased at Gibson Revetment, but it increased nearly 5 times at the Natchez Natural Bank. The macroinvertebrate assemblages found in the natural bank snag samples in the fall and winter were very similar to those found in the summer, i.e., caddisflies at Natchez and chironomids and oligochaetes at Port Sulphur. The Gibson and Fort Adams Revetments also showed relatively small overall seasonal changes (summer to winter) with regard to the invertebrates colonizing the ACM. However, the Port Sulphur Revetment taxa showed a distinct change in the fall, being comprised mostly of chironomids and oligochaetes at that time.

114. Although summer drift densities were low at both Gibson and Port Sulphur Revetments (Table 12), the pattern was the same as that for other macroinvertebrate collection methods, i.e., higher at Gibson Revetment. The number of taxa was also considerably higher at Gibson Revetment. *Chaoborus* sp. dominated at Gibson Revetment, while copepods were the most

common taxon at Port Sulphur Revetment. Densities of drifting invertebrates increased at both these banks in the fall (Table 13), up nearly 20 times at Port Sulphur but only about 2 times at Gibson. The number of taxa remained relatively similar at these revetments. Copepods remained dominant at Port Sulphur; chironomid pupae dominated at Gibson Revetment.

115. Invertebrates collected in core samples taken in the fall differed among the three revetted banks (Table 13). Tubificids were the most abundant taxon collected at Gibson Revetment (Table B4); the amphipod *Corophium* sp., tubificids, mayflies and caddisflies were all relativcly common at Fort Adams (Table B5); a mixture of amphipods and tubificids dominated at Port Sulphur (Table B6). Estimated densities, while all fairly low, also indicated differences among these banks, ranging from 140 to 620 organisms per square metre.

ACM modification experiments

116. Only 11 of the 36 experimental ACM blocks (5 with holes; 4 with grooves; 2 control) were retrieved at the Vicksburg site on 18 October 1985. At Port Sulphur, 23 of the original 24 blocks were retrieved on 3 October 1985; however, one other block had been disturbed and was not used. All blocks, and also the "Fish-Hab" strands, were covered with a growth of filamentous blue-green algae at Port Sulphur. Organisms were picked and counted from two complete "Fish-Hab" units and a 25 percent subsample was completed for the other four units, due to the extreme time needed to remove organisms from the algal strands.

117. Density, biomass, and mean number of taxa per block (Table 14) were all significantly greater overall at the Vicksburg site than at Port Sulphur (Table 15). No significant difference in density of organisms was detected among ACM modification types at either site. However, means densities on grooved blocks were considerably greater than that of any other modification type (or control). Number of taxa was significantly greater for grooved blocks than for other modifications at both sites, and biomass was clearly greater on grooved surfaces at the Marshall-Brown's Point Revetment. In addition species composition varied somewhat between sites. Hydropsychid caddisflies followed by the chironomid *Rheotanytarsus* sp. were by far the dominant macroinvertebrate groups collected at the Vicksburg site (Table C1). At the Port Sulphur site oligochaete worms (primarily *Nais pardalis*) and the chironomid *Dicrotendipes neomodestus* were the two most common groups collected.

Table 14

Density, Biomass, and Number of Taxa of Macroinvertebrates Observed in ACM Revetment Surface Modification Experiments

Location	Surface Modification	Number of Blocks Recovered	Mean Number of Taxa	Mean Density ($No./m^2$)	Mean Biomass (mg/m^2)*
Marshall-Brown's Point Revetment	Grooves	4	12.5	4797	1.40
	Holes	5	9.8	2521	0.31
	Control	2	8.5	2321	0.38
Mean			10.5	3312	0.79
Port Sulphur Revetment	Grooves	6	10.0	5299	0.04
	Holes	5	6.4	947	0.01
	"Fish-Hab"	6	7.7	2922	0.03
	Control	5	6.0	1140	0.02
Mean			7.6	2716	0.03

* Ash free dry weight.

Table 15

Summary of Statistical Test Results for the Revetment Surface Modification Experiments

Comparison	F-value		
	Marshall-Brown's Point Revetment		Port Sulfur Revetment
Density			
Overall-Between Sites		5.88*	
Control vs. Grooves	1.11^{ns}		2.23^{ns}
Control vs. Holes	0.01^{ns}		0.00^{ns}
Grooves vs. Holes	1.50^{ns}		2.12^{ns}
Grooves vs. Fish-Hab	--		0.44^{ns}
Holes vs. Fish-Hab	--		2.42^{ns}
Control vs. Fish-Hab	--		1.82^{ns}
Biomass			
Overall-Between Sites		20.69**	
Control vs. Grooves	1.74^{ns}		2.57^{ns}
Control vs. Holes	0.48^{ns}		0.07^{ns}
Grooves vs. Holes	6.57*		0.05^{ns}
Grooves vs. Fish-Hab	--		0.09^{ns}
Holes vs. Fish-Hab	--		2.58^{ns}
Control vs. Fish-Hab	--		1.75^{ns}
Number of Taxa			
Overall-Between Sites		9.94**	
Control vs. Grooves	7.28*		6.11*
Control vs. Holes	1.01^{ns}		0.06^{ns}
Grooves vs. Holes	4.97*		4.95*
Grooves vs. Fish-Hab	--		2.29^{ns}
Holes vs. Fish-Hab	--		0.61^{ns}
Control vs. Fish-Hab	--		1.06^{ns}

* = $0.05 > P > 0.01$; ** = $p < 0.01$; ns = not significant.

118. No detectable wear was observed for any block modification type after even one year.

PART V: DISCUSSION

119. Natural and revetted banks on the Lower Mississippi River provide different physical habitats for aquatic organisms. The differences are primarily in habitat features, particularly current speed and substrate type. Temperature, dissolved oxygen concentration, pH, conductivity, turbidity, oxidation-reduction potential, total organic carbon, and dissolved and suspended solids do not appear to differ meaningfully between these two bank types. Indeed, with the exception of water temperature in fall, these variables seem to show relatively little variation over nearly a 450-mile reach of the river.

120. Both natural and revetted banks offer two general types of substrates: sediments, and hard substrates relatively free of sediments. The extent and composition of these types of substrates differ markedly between the two bank types, however. Natural bank sediments are variable, consisting of a variety of sediment types including consolidated clays, sands, and gravel often occurring in strata. Sediments overlaying revetments at the study sites appear to be largely a mixture of unconsolidated fine sands and silt-clays. At any given stage perhaps only about one-half, or somewhat less, of the nearshore ACM was overlaid with sediment. Thus, sediments found along revetted banks are not only qualitatively different from those found on natural banks, they also provide quantitatively less sediment-type habitat per unit length of bank. The ACM itself, along with some riprap, comprises the hard substrate of revetted banks, while that of the natural banks is comprised of submerged snags. Although the surface area of snags per unit length of bankline has not been quantified for such a large river, revetments may provide considerably more hard, clean substrate.

121. Current speed, direction, and variability vary at several levels along both revetted and natural banks. On the largest scale, current speeds along the study banks were always lowest at Port Sulphur, although the small overall amount of bank studied makes it impossible to determine whether this generally true of this reach. On a smaller scale, current speeds in any reach seem to depend upon the exact position of the bank relative to the thalweg, the width of the channel in the reach, and the river stage. Bank sinuosity, and the occurrence of flow-blocking structures such as buckled ACM or large submerged snags create local changes in current direction and speed which may

vary on a scale of only a few feet. Our data, and several years of general field observations, suggest that the actual current speed and direction found at any given location are essentially independent of the type of bank (i.e., revetted or natural).

122. Despite the fact that revetted and natural banks, on the average, appear to be different, it is not possible to specify the attributes of a "typical" or "average" bank of either type. Position of the bank relative to the main channel thalweg, bank sinuosity, the presence or absence of submerged trees and brush, the type of sediment, the number and size of eddies, and river stage are among the many factors interacting to make each relatively small reach physically unique. Natural banks are more uniform than revetments.

123. The distributions of macroinvertebrates in large rivers are functions primarily of substrate and current speed (Beckett et al. 1983). Previous reports on the Lower Mississippi River biota (Mathis et al. 1980; Mathis, Bingham, and Sanders 1982; Wells and Demas 1979) have demonstrated that the functional relationship between macroinvertebrate taxa and physical conditions holds true for all river habitats studied to date, including abandoned channels, secondary channels, dike fields of several types, and natural banks. Natural bank faunas observed in this study were similar to those observed in earlier investigations on the Lower Mississippi River (Beckett et al. 1983). Until the present study, however, the distribution of macroinvertebrates along revetted banks was largely unknown (Beckett and Pennington 1986). Although substrate and current speeds varied considerably among the three revetments and along individual revetments, the same physical-biological associations were found. For example, areas of sand and relatively swift currents were inhabited primarily by the chironomids Robackia claviger and Chernovskiia orbicus, which exhibit a preference for this habitat type (Beckett et al. 1983). The clean revetment, where currents were moderate to swift, was colonized by caddisflies and certain chironomids, which are known to colonize dike structures constructed of riprap (stone) on the Lower Mississippi River (Mathis et al. 1982). Oligochaetes, typically tubificids at Gibson and Fort Adams revetments, and naidids at Port Sulphur revetment, dominated the overlaying sediments.

124. Differing proportions of sediments versus hard substrates, and differences in the types of sediments themselves can profoundly affect the

composition, density, and biomass of the macroinvertebrate assemblage, and thus affect the ecosystem of the entire river. Natural bank habitat of the Lower Mississippi River is rather unique in that two species of burrowing mayflies, *Tortopus incertus* and *Pentagenia vittigera* colonize the consolidated clays which make up a large portion of this habitat type. These particular mayflies appear to be "substrate specific" and are seldomly found in any other habitat types. Both *T. incertus* and *P. vittigera* are found in very high densities along stretches of natural banks in the Lower Mississippi River (Mathis et al. 1981) and are known to contribute appreciable biomass to the river ecosystem (Beckett and Pennington 1986). When ACM is placed on a natural bank there is a shift in invertebrate community composition. These areas are now characterized by caddisflies i.e. Hydropsyche sp., sprawling mayflies i.e. *Stenonema* sp., and chironomids i.e. *Rheotanytursus* sp. which are frequently found on stone substrates in rivers (Hynes 1972). Tubificid oligochetes and chironomids are predominant where sediments have been deposited on revetment surfaces. It should be noted that field observations have shown that in some areas where ACM has buckled and the clay substrate beneath it is exposed, both *P. vittigera* and *T. incertus* are usually present. Whether or not this shift in community composition between natural and revetted banks reflects a decrease or increase in overall secondary production in the river ecosystem is not known. In addition, the impact of change in community composition on other parts of the riverine biota, particularly fish, is presently unknown.

125. Based primarily on several earlier studies (NUS 1974; CDM/Limnetics 1976; Pennington et al. 1980; Pennington, Baker and Bond 1983), Pennington, Baker and Potter (1983) concluded that revetted and natural banks offered somewhat different habitats for fish, although the differences were quantitative rather than qualitative. They obtained similar overall faunal lists for the two bank types, but the relative abundances of the constituent species varied widely. They also found that revetted bank faunas varied more between sites and seasons than did natural bank faunas. In the present study, there appeared to be very little difference in fish assemblage structure between the two types of banks at the Natchez site in either season. At Port Sulphur, differences appeared to be much larger. However, our ability to seine effectively along the natural bank but not the revetment was responsible for

much of the difference in species composition. Unpublished data* for the Port Sulphur area, taken near the same time as data from this report, show that (when very large seines and special techniques are employed) the same species of small, near-shore fishes are found along both the revetments and natural banks. In our study, numerical differences in catches along the two banks at Port Sulphur primarily involved two euryhaline species, striped mullet and Atlantic stingray. Striped mullet probably vary considerably in abundance with season in the Lower Mississippi River, since this is typically a marine and estuarine species. Atlantic stingrays probably also do not maintain regular, large populations in the river. Thus, the major differences found between these two banks may be due to transient differences in the occurrence of certain species, and not related to intrinsic differences in the habitat values of the two types of banks to fish.

126. Recent LMREP investigations have added a significant new dimension to our knowledge of large-river fish populations with the incorporation of hydroacoustic technology to assess fish numbers, sizes, and spatial distributions. Although this method does not permit identification of species, it does, for the first time, allow estimates to be made of the characteristics of fish populations in relatively deep, fast habitats that cannot be sampled adequately with traditional gears. Therefore, data on the relative densities of fish along the five banks generated in this study by traditional gears and hydroacoustics should be viewed as complementary, not contradictory. This is particularly well illustrated by the data generated for the Port Sulphur Revetment. In both seasons, boat electroshocker catches indicated large numbers of fish (primarily striped mullet) very close to shore (<2 m deep). Very low fish densities were estimated for this bank using hydroacoustics, and the fish were primarily bottom-oriented in relatively deep water. The electroshocker was ineffective in water deeper than about 4 m, however, and the hydroacoustic system was similarly limited in water less than about 2 m deep. Combining information from the two techniques thus provided a more complete picture of fish spatial distribution along this bank.

127. Size distributions were also different for the gears. Striped mullet collected by electroshocking near shore averaged from 30 to 40 cm total length; hydroacoustic targets ranged from only an estimated 2 to 15 cm, with a

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mean size of only 4 cm. If the target strength to size relationship used in this study is accurate, these data suggest that different species were utilizing the shallow and deep areas along this bank. This suggestion is supported by the hoop net catches, which consisted almost entirely of bottom-oriented fish (catfishes and freshwater drum), taken in deeper water, and which were about 10 to 15 cm in length.

128. The value of eddies along revetments was demonstrated at the Gibson Revetment, where very high target counts were obtained in summer. The area of the eddy near transect A (actually large enough to be used as a site in the Eddy Study of the LMREP) produced the highest counts. This information would not have been available from sampling with traditional gears.

PART VI: SUMMARY AND CONCLUSIONS

129. Physical, chemical, and biological surveys were made along three revetted and two natural banks in the Lower Mississippi River during the summer and fall of 1985.

130. Measured water quality variables showed little meaningful difference among the five banks in either season, with the single exception of temperature, which was higher in the fall at the two Port Sulphur banks.

131. Current speeds and directions varied widely both among banks and among stations within individual banks, and they also varied considerably between seasons. Current speeds were consistently lowest at the two Port Sulphur banks, although whether this is a phenomenon common throughout that entire reach could not be determined.

132. Substrates of the two banks consisted of two general types: sediments; and hard substrates. Hard substrates of revetted banks were ACM and occasional riprap; those along natural banks consisted of submerged snags. About one-half of the ACM was typically overlayed with sediments, mostly unconsolidated fine sands and silt-clays, at any one season. The sediments of the natural banks, in contrast, consisted primarily of consolidated clays, with occasional sand and/or gravel areas.

133. Both traditional fish-collecting gears and hydroacoustics indicated differences in fish densities among the five banks, including differences between the two natural banks, among the three revetted banks, between the natural and revetted banks at Port Sulphur, and between seasons. In many cases, these two gear types provided dissimilar estimates of the ranking banks. However, their areas of spatial coverage are nearly exclusive, and their results should be interpreted as complementary rather than contradictory.

134. Hydroacoustics demonstrated considerable, though variable, differences in the distributions of fish along the five banks in terms of both lateral and vertical dimensions. The distributions of estimated fish sizes also showed variability among the banks and between seasons.

135. Very low numbers of target fish species were obtained which had food items in their stomachs. Blue catfish ate a variety of foods; flathead catfish ate mostly fish and shrimp.

136. The macroinvertebrate assemblages of the five banks were found to be considerably different, especially those along the revetments. The natural bank faunas showed somewhat more similarity. Overall, the macroinvertebrate assemblages reflected the conditions of current and substrate found at each particular sampling station. Seasonal effects were apparent, but appeared to be minor compared to physical habitat effects.

137. When revetment is placed along stretches of natural bank there is a shift in macroinvertebrate community composition. Those areas which were once colonized principally by burrowing mayflies are now colonized by macroinvertebrates which exhibit a preference for hard stable substrates such as ACM. In cases where the existing revetment is buckled however the underlying substrate may still be colonized by the burrowing mayflies.

138. In an experiment to determine the effect of ACM surface modifications upon benthic macroinvertebrates, ACM experimental blocks having numerous parallel grooves harbored denser populations than those with holes or commercial "Fish-hab," or control ACM blocks.

139. From the physical and biological data collected in this study, it does not appear possible to specify the attributes of a "typical" or "average" revetted or natural bank in the Lower Mississippi River. Variations in orientation of the bank with respect to the thalweg, bank sinousity, the presence of submerged current-deflecting structure (buckled ACM, trees and brush), the presence and size of eddies, and even season all interact to make each bank somewhat unique.

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APPENDIX A: FISH POPULATION DATA COLLECTED FROM FIVE LOWER MISSISSIPPI RIVER BANK HABITATS DURING SUMMER AND FALL 1985

Table A1

Taxonomic Classification of Fish Captured at Five Sites on the Lower Mississippi River

Family Common Name, Species
Dasyatidae - stingrays
Atlantic stingray (*Dasyatis sabina*)
Lepisosteidae - gars
Spotted gar (*Lepisosteus oculatus*)
Longnose gar (*Lepisosteus osseus*)
Shortnose gar (*Lepisosteus platostomus*)
Anguillidae - freshwater eels
American eel (*Anguilla rostrata*)
Clupeidae - herrings
Skipjack herring (*Alosa chrysochloris*)
Gizzard shad (*Dorosoma cepedianum*)
Threadfin shad (*Dorosoma petenense*)
Engraulidae - anchovies
Bay anchovy (*Anchoa mitchilli*)
Hiodontidae - mooneyes
Goldeye (*Hiodon alosoides*)
Cyprinidae - minnows and carps
Goldfish (*Carassius auratus*)
Common carp (*Cyprinus carpio*)
Mississippi silvery minnow (*Hybognatus nuchalis*)
Speckled chub (*Hybopsis aestivalis*)
Silver chub (*Hybopsis storeriana*)
Golden shiner (*Notemigonus crysoleucas*)
Emerald shiner (*Notropis atherinoides*)
River shiner (*Notropis blennius*)
Ghost shiner (*Notropis buchanani*)
Pugnose minnow (*Notropis emiliae*)
Red shiner (*Notropis lutrensis*)
Silverband shiner (*Notropis shumardi*)
Weed shiner (*Notropis texanus*)
Blacktail shiner (*Notropis venustus*)
Mimic shiner (*Notropis volucellus*)
Bullhead minnow (*Pimephales vigilax*)

(Continued)

(Sheet 1 of 3)

Table A1 (Continued)

Family Common Name, Species
Catostomidae - suckers
River carpsucker (*Carpiodes carpio*)
Blue sucker (*Cycleptus elongatus*)
Ictaluridae - freshwater catfishes
Blue catfish (*Ictalurus furcatus*)
Channel catfish (*Ictalurus punctatus*)
Flathead catfish (*Pylodictis olivaris*)
Belonidae - needlefishes
Atlantic needlefish (*Strongylura marina*)
Cyprinodontidae - killifishes
Blackspotted topminnow (*Fundulus olivaceus*)
Bayou killifish (*Fundulus pulvereus*)
Poeciliidae - livebearers
Mosquitofish (*Gambusia affinis*)
Atherinidae - silversides
Brook silverside (*Labidesthes sicculus*)
Rough silverside (*Membras martinica*)
Inland silverside (*Menidia beryllina*)
Percichthyidae - temperate basses
White bass (*Morone chrysops*)
Yellow bass (*Morone mississippiensis*)
Striped bass (*Morone saxatilis*)
Centrarchidae - sunfishes
Green sunfish (*Lepomis cyanellus*)
Orangespotted sunfish (*Lepomis humulis*)
Bluegill (*Lepomis macrochirus*)
Longear sunfish (*Lepomis megalotis*)
Largemouth bass (*Micropterus salmoides*)
White crappie (*Pomoxis annularis*)
Black crappie (*Pomoxis nigromaculatus*)
Percidae - perches
Bluntnose darter (*Etheostoma chorosomum*)
River darter (*Percina shumardi*)
Sauger (*Stizostedion canadense*)

(Continued)

(Sheet 2 of 3)

Table A1 (Concluded)

Family Common Name, Species
Haemulidae - grunts
Pigfish (*Orthopristis chrysoptera*)
Carangidae - jacks
Crevalle jack (*Caranx hippos*)
Sciaenidae - drums
Freshwater drum (*Aplodinotus grunniens*)
Red drum (*Sciaenops ocellatus*)
Mugilidae - mullets
Striped mullet (*Mugil cephalus*)
Gobiidae - gobies
Freshwater goby (*Gobionellus shufeldti*)
Bothidae - lefteye flounders
Southern flounder (*Paralichthys lethostigma*)

(Sheet 3 of 3)

Table A2

Numbers and Weights of Fishes Collected from Gibson Revetment*

Species	Summer Hoop Nets	Summer Seine	Summer Boat Shocker	Summer Backpack Shocker	Summer Total	Fall Hoop Nets	Fall Seine	Fall Boat Shocker	Fall Backpack Shocker	Fall Total
Longnose gar			2 (2,488)	1 (0.1)	3 (2,488.1)					
Shortnose gar			2 (1,066)		2 (1,066)			1 (187)		1 (187)
American eel	1 (715)				1 (715)					
Skipjack herring			1 (190)		1 (190)			1 (136)		1 (136)
Gizzard shad	1 (92)	3 (6.1)	11 (2,851)		15 (2,949.0)		1 (9.3)	37 (4,268)		38 (4,277.3)
Threadfin shad		108 (53.6)	9 (123.2)	1 (0.1)	118 (176.9)		14 (44.5)	13 (153)		27 (197.5)
Common carp								7 (12,890)		7 (12,890)
Mississippi silvery minnow		19 (13.9)			19 (13.9)					
Silver chub		17 (5.7)			17 (5.7)					
Golden shiner		1 (0.5)			1 (0.5)					
Emerald shiner		2 (1.7)			2 (1.7)		8 (12.2)		1 (1.8)	
River shiner		5 (7.8)			5 (7.8)		2 (0.5)			9 (14)
Ghost shiner		7 (1.8)			7 (1.8)					2 (0.5)
Red shiner				4 (7.6)	4 (7.6)					

(Continued)

* Top figure gives the total number of fish collected; bottom figure, in parentheses, gives the total weight in grams.

(Sheet 1 of 3)

Table A2 (Continued)

Species	Summer					Fall				
	Hoop Nets	Seine	Boat Shocker	Backpack Shocker	Total	Hoop Nets	Seine	Boat Shocker	Backpack Shocker	Total
Silverband shiner		1 (1.0)		1 (0.4)	2 (1.4)		18 (8.0)			18 (8.0)
Blacktail shiner				3 (4.5)	3 (4.5)		1 (0.1)			1 (0.1)
Mimic shiner		15 (7.9)			15 (7.9)					
Bullhead minnow		3 (2.9)			3 (2.9)					
River carpsucker								1 (91)		1 (91)
Blue catfish	4 (342)	1 (13.9)	2 (485)		7 (840.9)	6 (669)		1 (130)		7 (799)
Channel catfish		1 (3.7)			1 (3.7)		4 (11.3)	2 (572.9)		6 (583.2)
Flathead catfish	5 (12,170)				5 (12,170)	4 (2779)		1 (982)		5 (3761)
Mosquito fish		1 (0.1)		1 (0.1)	2 (0.2)					
Brook silverside							1 (1.0)			1 (1.0)
Inland silverside		9 (4.0)		1 (0.4)	10 (4.4)		1 (0.1)			1 (0.1)
White bass		34 (45.1)	1 (700)		35 (745.1)			10 (2,207)		10 (2,207)
Orangespotted sunfish				1 (0.2)	1 (0.2)					
Bluegill							1 (1.3)	2 (139)	1 (25.5)	4 (165.8)
Longear sunfish								1 (1.5)		1 (1.5)

(Continued)

(Sheet 2 of 3)

Table A2 (Concluded)

Species	Summer					Fall				
	Hoop Nets	Seine	Boat Shocker	Backpack Shocker	Total	Hoop Nets	Seine	Boat Shocker	Backpack Shocker	Total
White crappie		2 (101)	2 (620)		4 (721)			3 (609)		3 (609)
River darter		4 (1.3)			4 (1.3)					
Sauger		1 (2.8)			1 (2.8)					
Freshwater drum	3 (502)	1 (0.4)	2 (270)		6 (772.4)					
Striped mullet			10 (4,145)		10 (4,145)			6 (2,644)		6 (2,544)
Total	14 (13,821)	235 (275.2)	42 (12,938.2)	13 (13.4)	304 (27,047.8)	10 (3,448)	51 (88.3)	86 (25,010.4)	2 (27.3)	149 (28,574)

(Sheet 3 of 3)

Table A3

Numbers and Weights of Fishes Collected from Natchez Natural Bank*

Species	Summer Hoop Nets	Summer Seine	Summer Boat Shocker	Summer Backpack Shocker	Summer Total	Fall Hoop Nets	Fall Seine	Fall Boat Shocker	Fall Backpack Shocker	Fall Total
Longnose gar			1 (448)		1 (448)					
Shortnose gar	1 (656)		1 (270)		2 (926)					
Skipjack herring			3 (164)		3 (164)			3 (450)		3 (450)
Gizzard shad			16 (2,889)		16 (2,889)		2 (11.0)	45 (6,229)		47 (6,240)
Threadfin shad		46 (15.7)	12 (205)		58 (220.7)		10 (37.5)	2 (24)	5 (16.6)	17 (78.1)
Goldeye								2 (378)		2 (378)
Common carp								2 (4,716)		2 (4,716)
Mississippi silvery minnow		6 (4.8)			6 (4.8)					
Silver chub		17 (5.8)			17 (5.8)					
Emerald shiner		3 (0.5)			3 (0.5)		6 (12.6)			6 (12.6)
River shiner		8 (18.3)			8 (18.3)				2 (5.1)	2 (5.1)
Pugnose minnow		1 (0.1)			1 (0.1)					
Red shiner		1 (0.3)			1 (0.3)					
Silverband shiner		2 (0.2)			2 (0.2)		19 (15.2)			19 (15.2)

(Continued)

* Top figure gives the total number of fish collected; bottom figure, in parentheses, gives the total weight in grams.

(Sheet 1 of 3)

Table A3 (Continued)

Species	Summer					Fall				
	Hoop Nets	Seine	Boat Shocker	Backpack Shocker	Total	Hoop Nets	Seine	Boat Shocker	Backpack Shocker	Total
Weed shiner		2 (0.7)			2 (0.7)					
Blacktail shiner		6 (4.4)			6 (4.4)		1 (0.2)			1 (0.2)
Mimic shiner		6 (2.4)			6 (2.4)					
Bullhead minnow		4 (8.0)			4 (8.0)					
Blue sucker								1 (764)		1 (764)
Blue catfish	1 (156)	1 (6.7)	2 (149)		4 (311.7)	3 (390)	2 (18.3)	18 (3,855)		23 (4,263.3)
Channel catfish		1 (13.1)			1 (13.1)		1 (4.9)			1 (4.9)
Flathead catfish	6 (4,490)		1 (387)		7 (4,877)	3 (2,215)		2 (696)		5 (2,911)
Blackspotted topminnow		2 (0.3)			2 (0.3)					
Inland silverside		15 (4.0)			15 (4.0)		5 (12.8)		1 (2.3)	6 (15.1)
White bass		16 (26.6)	3 (1,485)	1 (4.7)	20 (1,516.3)			4 (337)	2 (136.7)	6 (473.7)
Green sunfish		2 (0.2)			2 (0.2)					
Orangespotted sunfish		2 (10.4)			2 (10.4)					
Bluegill		1 (0.1)			1 (0.1)		1 (1.0)			1 (1.0)
White crappie		2 (1.1)	1 (104)		3 (105.1)					

(Continued)

(Sheet 2 of 3)

Table A3 (Concluded)

Species	Summer Hoop Nets	Summer Seine	Summer Boat Shocker	Summer Backpack Shocker	Summer Total	Fall Hoop Nets	Fall Seine	Fall Boat Shocker	Fall Backpack Shocker	Fall Total
Freshwater drum	5 (3,552)	1 (0.1)			6 (3,552.1)	3 (480)		4 (2,296)		7 (2,776)
Striped mullet			6 (2,209)		6 (2,209)			1 (231)		1 (231)
Total	13 (8,854)	145 (123.8)	46 (8,310)	1 (4.7)	205 (17,292.5)	9 (3,085)	47 (113.5)	84 (19,976)	10 (160.7)	150 (23,335.2)

(Sheet 3 of 3)

Table A4

Numbers and Weights of Fishes Collected from Fort Adams Revetment*

Species	Summer					Fall				
	Hoop Nets	Seine	Boat Shocker	Backpack Shocker	Total	Hoop Nets	Seine	Boat Shocker	Backpack Shocker	Total
American eel			1 (9.0)		1 (9.0)	1 (700)				1 (700)
Skipjack herring			13 (966)		13 (966)			1 (26)		1 (26)
Gizzard shad			77 (6,241)		77 (6,241)		5 (212.4)	61 (6,559)	2 (37)	68 (6,808.4)
Threadfin shad		104 (49.7)	5 (86)	2 (32.6)	111 (168.3)			14 (197.8)	3 (31.6)	17 (229.4)
Goldeye			3 (458)		3 (458)					
Goldfish				1 (66.9)	1 (66.9)					
Common carp			6 (12,131)		6 (12,131)		1 (387)	13 (39,644)		14 (40,031)
Mississippi silvery minnow		1 (0.7)			1 (0.7)					
Speckled chub							1 (0.4)			1 (0.4)
Silver chub		6 (3.4)			6 (3.4)				4 (25.9)	4 (25.9)
Emerald shiner		12 (3.2)			12 (3.2)					
River shiner		3 (5.4)			3 (5.4)					
Red shiner		3 (1.7)		1 (1.8)	4 (3.5)					
Silverband shiner		6 (5.1)			6 (5.1)		2 (4.3)			2 (4.3)

(Continued)

* Top figure gives the total number of fish collected; bottom figure, in parentheses, gives the total weight in grams.

Table A4 (Concluded)

Species	Summer					Fall				
	Hoop Nets	Seine	Boat Shocker	Backpack Shocker	Total	Hoop Nets	Seine	Boat Shocker	Backpack Shocker	Total
Blacktail shiner		5 (4.3)		1 (1.1)	6 (5.4)					
Bullhead minnow							1 (1.0)			1 (1.0)
River carpsucker						1 (475)		3 (1,172)		4 (1,647)
Blue catfish	1 (173)		1 (5.0)		2 (178.0)	1 (95)		19 (1,742.6)		20 (1,837.6)
Channel catfish			1 (759)		1 (759)					
Flathead catfish	6 (10,901)		17 (6,224)		23 (17,125)	7 (14,530)		9 (4,884)		16 (19,414)
Brook silverside							1 (2.3)			1 (2.3)
Inland silverside		65 (27.2)		2 (0.4)	67 (27.6)		12 (40.4)			12 (40.4)
White bass		4 (1.5)	8 (2,269)		12 (2,270.5)	1 (475)		11 (2,725)		12 (3,200)
Bluegill		1 (0.1)			1 (0.1)				1 (0.6)	1 (0.6)
Longear sunfish				1 (9.2)	1 (9.2)					
White crappie			1 (41)		1 (41)					
Bluntnose darter		1 (0.1)			1 (0.1)					
Sauger								1 (63.9)		1 (63.9)
Freshwater drum	3 (3,461)		3 (375)		6 (3,836)			2 (188)		2 (188)
Striped mullet			14 (3,542)		14 (3,542)			31 (13,780)	4 (1,503)	35 (15,283)
Total	10 (14,535)	211 (102.4)	150 (33,101)	8 (112)	379 (47,855.4)	11 (16,275)	23 (647.8)	165 (70,982.3)	14 (1,598.1)	213 (89,503.2)

Table A5

Numbers and Weights of Fishes Collected from Port Sulfur Revetment*

Species	Summer Hoop Nets	Summer Seine**	Summer Boat Shocker	Summer Backpack Shocker	Summer Total	Fall Hoop Nets	Fall Seine**	Fall Boat Shocker	Fall Backpack Shocker†	Fall Total
American eel	1 (399)		10 (1,199)	1 (225)	12 (1,823)			2 (85)		2 (85)
Skipjack herring			6 (472)		6 (472)					
Gizzard shad			1 (11.5)		1 (11.5)					
Common carp			1 (1,179)		1 (1,179)					
Blue catfish	2 (158)				2 (158)	3 (297)				3 (297)
Channel catfish	4 (1,485)		4 (2,224)		8 (3,709)	1 (187)		1 (291)		2 (478)
Flathead catfish	2 (2,284)				2 (2,284)					
Atlantic needlefish			2 (103)		2 (103)					
Rough silverside			7 (34.1)		7 (34.1)					
White bass						1 (338)		3 (448)		4 (786)
Yellow bass			2 (514)		2 (514)	1 (60)				1 (60)
Striped bass			2 (1,491)		2 (1,491)	1 (35)				1 (35)
Largemouth bass								1 (363)		1 (363)

(Continued)

* Top figure gives the total number of fish collected; bottom figure, in parentheses, gives the total weight in grams.

** Use of this gear was precluded by roughness of the revetment.

† Gear employed but no fish captured.

Table A5 (Concluded)

Species	Summer Hoop Nets	Summer Seine**	Summer Boat Shocker	Summer Backpack Shocker	Summer Total	Fall Hoop Nets	Fall Seine**	Fall Boat Shocker	Fall Backpack Shocker	Fall Total
Black crappie						1 (326)				1 (326)
Pigfish						1 (48.4)				1 (48.4)
Freshwater drum	9 (1,386)		2 (246)		11 (1,632)	2 (335)				2 (335)
Red drum								1 (217)		1 (217)
Striped mullet			283 (62,463)	15 (3,979.2)	298 (66,442.2)			157 (46,865)		157 (46,865)
Southern flounder			2 (1,395)	1 (450)	3 (1,845)					
Total	18 (5,712)		322 (71,331.6)	17 (4,654.2)	347 (81,697.8)	11 (1,626.4)		165 (48,269)		176 (49,895.4)

Table A6

Numbers and Weights of Fishes Collected from Port Sulphur Natural Bank*

Species	Summer Hoop Nets	Summer Seine	Summer Boat Shocker	Summer Backpack Shocker	Summer Total	Fall Hoop Nets	Fall Seine	Fall Boat Shocker	Fall Backpack Shocker**	Fall Total
Atlantic stingray	15 (19,034)				15 (19,034)					
Spotted gar		1 (748)			1 (748)					
Skipjack herring								1 (87)		1 (87)
Gizzard shad				1 (0.9)	1 (0.9)			1 (80)		1 (80)
Threadfin shad			2 (33)		2 (33)					
Bay anchovy		94 (15.1)			94 (15.1)		138 (25.5)			138 (25.5)
Goldeye		1 (1.7)			1 (1.7)					
Silver chub		3 (1.8)			3 (1.8)					
Emerald shiner		3 (0.7)			3 (0.7)					
Blue catfish			1 (437)	1 (1,550)	2 (1,987)					
Channel catfish	2 (897)	2 (10.9)	2 (2,081)		6 (2,988.9)					
Flathead catfish	4 (8,620)				4 (8,620)					
Atlantic needlefish			1 (30)		1 (30)			1 (21)		1 (21)

(Continued)

* Top figure gives the total number of fish collected; bottom figure, in parentheses, gives the total weight in grams.
** Gear was used but no fish were captured.

Table A6 (Concluded)

Species	Summer Hoop Nets	Summer Seine	Summer Boat Shocker	Summer Backpack Shocker	Summer Total	Fall Hoop Nets	Fall Seine	Fall Boat Shocker	Fall Backpack Shocker**	Fall Total
Bayou killifish		1 (3.2)			1 (3.2)					
Inland silverside		1 (0.3)			1 (0.3)					
White bass		1 (0.1)			1 (0.1)			3 (557)		3 (557)
Striped bass	1 (80)		1 (1,195)		2 (1,275)	1 (188)	1 (8.2)			2 (196.2)
Crevalle jack								1 (18.9)		1 (18.9)
Pigfish						1 (57.8)				1 (57.8)
Freshwater drum	13 (8,965)	2 (0.3)	2 (772)		17 (9,737.3)	4 (1,178)		2 (259)		6 (1,437)
Striped mullet			8 (1,824)	2 (450.2)	10 (2,274.2)			80 (36,467)		80 (36,467)
Freshwater goby							1 (0.5)			1 (0.5)
Southern flounder			1 (389)							
Total	35 (37,596)	109 (782.1)	18 (6,761)	4 (2,001.1)	166 (47,140.2)	6 (1,423.8)	140 (34.2)	89 (37,489.9)	0 (0)	235 (38,947.9)

APPENDIX B: MACROINVERTEBRATE DATA COLLECTED FROM FIVE LOWER MISSISSIPPI RIVER BANK HABITATS DURING SUMMER AND FALL/WINTER 1985

Table B1

Macroinvertebrate Taxa and Estimated Densities Per Square Metre Collected from the Lower Mississippi River Near Natchez, Mississippi, Summer 1985*

Taxon	Gibson Revetment					Natchez Natural Bank	
	Shipek Grab	Hess	ACM Slabs	Core	Drift	Shipek Grab	Snags
Diptera							
Diptera pupae		12			1		10
Culicidae							
Chaoborus		12			12		2
Chironomidae							
Chironomidae pupae					1		
Orthocladiinae							
Nanocladius distinctus			1				15
Thienemanniella sp.							16
Tanypodinae							
Ablabesmyia annulata					1		
Ablabesmyia mallochi			1				
Coelotanypus sp.	24						
Chironominae							1
Chernovskiia orbicus							
Chironomus sp. 2					1	900	
Cryptochironomus sp.	291						
Glyptotendipes sp.					1		
Harnisha curtilamellata	73				1		
Phaenopsectra sp.		48					1
Polypedilum convictum			13				72
Polypedilum halterale							2
Polypedilum illinoense						1	2
Rheotanytarsus sp.		96	3				25
Robackia claviger		12				150	
Stelechomyia perpulchra							1
Stenochironomus sp.		12					112

(Continued)

* Densities are in numbers per m^2, except for drift, which is in numbers per 100 m^3.

(Sheet 1 of 4)

Table B1 (Continued)

Taxon	Gibson Revetment Shipek Grab	Gibson Revetment Hess	Gibson Revetment ACM Slabs	Gibson Revetment Core	Gibson Revetment Drift	Natchez Natural Bank Shipek Grab	Natchez Natural Bank Snags
Isopoda							
Asellidae							
Lirceus sp.			6				
Amphipoda							
Gammaridae							
Crangonyx sp.			1				
Gammarus sp.		60	13		1		
Corophiidae							
Corophium sp.			1				
Gastropoda	24	72	8		1		
Goniobasis sp.			2				
Pelecypoda		12				270	
Corbicula fluminea					1	340	
Ephemeroptera			1				5
Baetidae							
Baetis sp.		12			1		
Ephemeridae							
Hexagenia sp.	97						
Heptageniidae		12	1				
Stenonema integrum			6		1		3
Polymitarcyidae							
Tortopus incertus		12	1		1	3,400	
Odonata							
Anisoptera						20	
Somatochlora sp.							1
Trichoptera							
Trichoptera pupae							7
Hydropsychidae		565			1		285
Hydropsychidae early instars		2,306	887				514
Hydropsyche orris		6,424	1,066		2	364	1,125
Potamyia flava		48	3		1		

(Continued)

(Sheet 2 of 4)

Table B1 (Continued)

Taxon	Gibson Revetment					Natchez Natural Bank	
	Shipek Grab	Hess	ACM Slabs	Core	Drift	Shipek Grab	Snags
Hydroptilidae							
Neotrichia sp.			1			22	8
Polycentropdidae							
Neureclipsis sp.		35	8				1
Leptoceridae							
Nectopsyche sp.					1		
Microturbellaria						22	
Turbellaria							
Tricladida							
Dugesia tigrina	24						
Nematoda						194	3
Annelida							
Naididae							
Homochaeta naidina	291						
Nais behningi							1
Tubificidae							
Aulodrilus pigueti	97						
Aulodrilus pluriseta	49						
Limnodrilus hoffmeisteri	49						
Limnodrilus maumeensis	2,791						
Limnodrilus udekemianus	73						
Tubificidae (nc)**	6,675	24				22	
Hydracarina					1		
Copepoda					3		
Arguliidae							
Argulus sp.					1		
Mysidacea							
Mysidae							
Taphromysis louisianae					7		1

(Continued)

** (c) = immature tubificids with capilliform chaetae; (nc) = immature tubificids lacking such chaetae.

(Sheet 3 of 4)

Table B1 (Concluded)

Taxon	Gibson Revetment					Natchez Natural Bank	
	Shipek Grab	Hess	ACM Slabs	Core	Drift	Shipek Grab	Snags
Decapoda							
Palaemonidae							
Macrobrachium ohione					1		
Coleoptera							
Chrysomelidae					1		
Hemiptera							
Notonectidae					1		
Hymenoptera					1		
Total/m^2	10,558	9,775	2,023		47	5,704	2,213

(Sheet 4 of 4)

Table B2

Macroinvertebrate Taxa and Estimated Densities
Per Square Metre Collected from the Lower Mississippi River
Near Tunica Bend, Louisiana, Summer 1985*

Taxon	Fort Adams Revetment: Shipek Grab	Hess	ACM Slabs
Diptera			
Chironomidae			
Chironominae			
Chernovskiia orbicus	122		
Rheotanytarsus sp.	24		
Isopoda			
Asellidae			
Asxellus sp.			1
Lirceus sp.			4
Amphipoda			
Gammaridae			
Gammarus sp.	24		2
Corophidae			
Corophium sp.			3
Gastropoda	97	47	5
Pelecypoda			
Corbicula fluminea	24		
Ephemeroptera			2
Ephemeridae			
Pentagenia sp.	73		
Heptageniidae			
Stenonema integrum			27
Stenonema interpunctatum			1
Stenonema sp.			1
Polymitarcyidae			
Tortopus incertus			1
Trichoptera			
Hydropsychidae			
Hydropsychidae early instar			2
Hydropsyche orris	24		8
Potamyia flava	24		
Hydroptilidae			
Neotrichia sp.			1
Polycentropiidae			
Neureclipsis sp.			2
Turbellaria			1
Tricladida			
Dugesia tigrina	122		

(Continued)

* Densities are in numbers per m^2.

Table B2 (Concluded)

Taxon	Fort Adams Revetment Shipek Grab	Hess	ACM Slabs
Annelida			
Naididae			
Stylurus sp.	24		
Tubificidae			
Tubificidae (nc)**	49		
Cordylophora		+	
Total/m^2	607	47	61

** (nc) indicates immature tubificids without capilliform chaetae.
\+ Colonial forms not included in Total Count.

Table B3

Macroinvertebrate Taxa and Estimated Densities Per Square Metre Collected from the Lower Mississippi River Near Port Sulphur, Louisiana, Summer 1985*

Taxon	Port Sulphur Revetment					Port Sulphur Natural Bank	
	Shipek Grab	Hess	ACM Slabs	Core	Drift	Shipek Grab	Snags
Diptera							
Diptera pupae					1		
Culicidae							
Chaoborus sp.					1		
Chironomidae							
Chironomidae pupae				20	1		1
Orthocladiinae							
Cricotopus sp.							4
Nanocladius distinctus							2
Tanypodinae							
Coelotanypus sp.	24						
Chironominae							
Cryptochironomus sp.			2	20		146	
Dicrotendipes nervosus I			1				26
Einfeldia sp.							1
Glyptotendipes sp.							4
Harnisha curtilamellata	49						
Phaenopsectra sp.							2
Polypedilum convictum							2
Polypedilum halterale							6
Polypedilum illinoense							4
Polypedilum nr. *scalaenum*							10
Stenochironomus sp.							14
Copepoda		12					
Isopoda							
Asellidae							
Lirceus sp.	24		5	40			
Amphipoda							

(Continued)

* Densities in numbers per m^2, except drift, which is in numbers per 100 m^3.

(Sheet 1 of 3)

Table B3 (Continued)

Taxon	Port Sulphur Revetment: Shipek Grab	Port Sulphur Revetment: Hess	Port Sulphur Revetment: ACM Slabs	Port Sulphur Revetment: Core	Port Sulphur Revetment: Drift	Port Sulphur Natural Bank: Shipek Grab	Port Sulphur Natural Bank: Snags
Gammaridae							
Crangonyx sp.			4	60			
Gammarus sp.	24	141	50	120	1	146	6
Corophidae							
Corophium sp.			1				2
Copepoda					3		
Argulidae							
Argulus sp.					1		
Mysidacea							
Mysidae							
Taphromysis louisianae					1		
Pelecypoda	24						
Emphemeroptera							
Ephemeridae							
Pentagenia sp.		12			1	874	
Heptageniidae							
Stenonema integrum		12	1				
Polymitarcyidae							
Tortopus incertus						194	
Trichoptera							
Hydropsychidae							
Hydropsyche orris				20			
Potamyia flava							2
Collembola							2
Annelida							
Enchytraeidae							2
Hirudinea							
Helobdella sp.			7	20			
Oligochaeta							
Naididae							
Nais communis							1
Nais elinguis			5	40			1
Uncinais uncinata	24						

(Continued)

(Sheet 2 of 3)

Table B3 (Concluded)

Taxon	Port Sulphur Revetment: Shipek Grab	Port Sulphur Revetment: Hess	Port Sulphur Revetment: ACM Slabs	Port Sulphur Revetment: Core	Port Sulphur Revetment: Drift	Port Sulphur Natural Bank: Shipek Grab	Port Sulphur Natural Bank: Snags
Tubificidae							
Aulodrilus pigueti	24						
Aulodrilus pluriseta			1				
Limnodrilus hoffmeisteri	24				1		
Limnodrilus maumeensis	24					97	
Tubificidae (nc)**	413		19		2	121	4
Tubificidae (c)	24		1	20			
Polychaeta							
Spionidae						97	
Coelenterata							
Hydra sp.	+						
Total/m^2	678	177	97	360	13	1,675	96

\+ Colonial forms not included in total count.
** (c) indicates immature tubificids with capilliform chaetae; (nc) indicates those lacking capilliform chaetae.

(Sheet 3 of 3)

Table B4

Macroinvertebrate Taxa and Estimated Densities
Per Square Metre Collected from the Lower Mississippi River
Near Natchez, Mississippi, Fall 1985*

Taxon	Gibson Revetment					Natchez Natural Bank	
	Shipek Grab	Hess	ACM Slabs	Core	Drift	Shipek Grab	Snags
Diptera							
Culicidae							
Chaoborus					1	24	
Heleidae							
Bezzia	24						
Chironomidae							
Chironomidae pupae	680	23			57		
Orthocladiinae							
Cricotopus intersectus			8				
Cricotopus sp.		153	18				
Nanocladius distinctus	97	12	6		1		1
Nanocladius sp.			2				2
Orthocladius sp.			58				2
Tanypodinae							
Ablabesmyia annulata					1		
Coeletanypus	97					24	
Larsia	24						
Procladius	49					49	
Tanypus stellatus			2		1	24	
Chironominae							
Chernovskiia orbicus	24				1	292	
Cryptochironomus sp.	73					73	
Dicrotendipes sp.		12					
Dicrotendipes nervosus I			4				
Glyptotendipes							1
Goeldichironomus pictus		12	8				
Harnisha curtilamellata	218					218	
Hydrobaenus pilipes		35	13				4
Phaenopsectra sp.							3

(Continued)

* Densities are in numbers per m^2, except drift, which is in numbers per 100 m^3.

(Sheet 1 of 4)

Table B4 (Continued)

Taxon	Gibson Revetment Shipek Grab	Hess	ACM Slabs	Core	Drift	Natchez Natural Bank Shipek Grab	Snags
Polypedilum convictum	97	23	26	20			6
Polypedilum halterale							2
Rheotanytarsus sp.	6772	247	66		3		1
Robackia claviger						146	
Stenochironomus sp.						24	
Copepoda		141			15		
Argulus sp.					1		
Formicidae					1		
Corixidae					1		
Mysidacea							
Mysidae							
Taphromysis louisianae					1		
Coelenterata							
Cordylophora					+	+	
Hydra	+				+		
Amphipoda							
Coraphidae							
Corophium sp.	461	35	12		2	24	3
Gammaridae					1		
Gammarus sp.				20	1		
Isopoda							
Asellidae							
Lirceus sp.			2				
Gastropoda	388		3				
Pelecypoda	73				1	413	
Corbiculidae							
Corbicula fluminea	49					97	
Arachnida	24						
Cladocera							
Daphnia		47			23		
Ephemeroptera							

(Continued)

+ indicates the presence of taxa for which counts are not possible (colonial forms).

(Sheet 2 of 4)

Table B4 (Continued)

Taxon	Gibson Revetment: Shipek Grab	Gibson Revetment: Hess	Gibson Revetment: ACM Slabs	Gibson Revetment: Core	Gibson Revetment: Drift	Natchez Natural Bank: Shipek Grab	Natchez Natural Bank: Snags
Baetidae							
Baetis sp.							
Ephemeridae							
Hexagenia sp.	97				1	49	
Pentagenia sp.	24				1	24	
Heptageniidae	24	12	2		1		
Stenonema integrum		12	82				9
Polymitarcyidae							
Tortopus incertus	24						
Plecoptera							
Perlodidae			1				3
Hydroperla sp.			1				3
Odonata							
Gomphidae							
Dromogomphus sp.	24						
Macromiidae							
Didymops Trans							3
Taeniopterygidae							
Taeniopteryx sp.			1				
Trichoptera							
Hydropsychidae							
Hydropsychidae early instar	121	141	104		3		241
Hydropsyche orris	49	341	137		1		1,274
Potamyia flava	49	59	28				
Hydroptilidae							1
Neotrichia					1		
Leptoceridae					1		
Nectopsyche sp.	24						
Polycentropiidae					1		
Neureclipsis sp.	24						3
Turbellaria							
Tricladida							
Dugesia tigrina	49						

(Continued)

(Sheet 3 of 4)

Table B4 (Concluded)

Taxon	Gibson Revetment Shipek Grab	Hess	ACM Slabs	Core	Drift	Natchez Natural Bank Shipek Grab	Snags
Microturbellaria	73					121	
Nematoda	73	24	1		1		
Annelida							
Oligochaeta							
Tubificidae							
Branchiura sowerbyi	438					73	
Limnodrilus cervix	291					49	
Limnodrilus hoffmeisteri	194			20		24	
Limnodrilus maumeensis	4,685					97	
Tubificidae (nc)**	15,000		1	220		1,019	
Tubificidae (c)	24					121	
Naididae							
Nais pardalis	24						
Nais variabilis			1				
Total/m^2	30,461	1,329	587	280	124	2,985	1,562

** (c) indicates immature tubificids possessing capilliform chaetae; (nc) indicates forms without capilliform chaetae.

(Sheet 4 of 4)

Table B5

Macroinvertebrate Taxa and Estimated Densities
Per Square Metre Collected from the Lower Mississippi River
Near Tunica Bend, Louisiana, Fall 1985*

Taxon	Fort Adams Revetment			
	Shipek Grab	Hess	Slabs	ACM Core
Diptera				
Culicidae				
Chaoborus sp.	49			
Chironomidae				
Chironomidae pupae	340			
Orthocladiinae				
Nanocladius distinctus			2	
Orthocladius sp.		23	34	
Tanypodinae				
Coelotanypus sp.	170			
Procladius sp.	24			
Chironominae				
Cryptochironomus sp.	24		2	
Dicrotendipes neomodestus		12	4	
Dicrotendipes nervosus I			4	
Glyptotendipes sp.			2	
Goeldichironomus pictus			2	
Harnisha curtilamellata	510			
Hydrobaenus pilipes		35	4	
Polypedilum convictum			7	
Polypedilum halterale	24			
Rheotanytarsus sp.	3,738	12	6	
Stenochironomus sp.	24			
Copepoda	24	212	1	
Cladocera				
Daphnia sp.		23		
Amphipoda				
Corophidae				
Corophium sp.	243	129	38	60
Gammaridae				
Crangonyx sp.			1	
Gammarus sp.	49		7	
Isopoda				
Ascellidae				
Lirceus sp.			4	
Gastropoda	267		4	
Mesogastropoda	24			
Pelecypoda	24			
Formicidae			1	
Ephemeroptera				
Ephemeridae				

(Continued)

* Densities are in numbers per m^2.

Table B5 (Concluded)

Taxon	Fort Adams Revetment: Shipek Grab	Hess	ACM Slabs	Core
Hexagenia sp.	97			
Pentagenia sp.	24	12		
Heptageniidae	24	12		20
Stenonema integrum			101	
Stenonema interpunctatum			1	
Plecoptera				
Perlodidae				
Hydroperla sp.			3	
Odonata				
Gomphidae				
Dromogomphus sp.	24			
Trichoptera				
Hydropsychidae				
Hydropsychidae early instar	170	59	28	
Hydropsyche orris		12	60	20
Potamyia flava	24		5	
Polycentropiidae				
Neureclipsis sp.			1	
Turbellaria				
Tricladida				
Dugesia tigrina	316			
Nematoda	24			
Annelida				
Oligochaeta				
Tubificidae				
Branchiura sowerbyi	607			
Limnodrilus cervix				20
Limnodrilus maumeensis	1748			
Tubificidae (nc)**	9321	12		20
Tubificidae (c)	291		1	
Coelenterata				
Hydra	+		+	
Cordylophora	+			
Total/m^2	18,204	553	323	140

** (c) indicates immature tubificids possessing capilliform chaetae; (nc) indicates forms without capilliform chaetae.

\+ indicates the presence of taxa for which counts cannot be made (colonial forms).

Table B6

Macroinvertebrate Taxa and Estimated Densities Per Square Metre Collected from the Lower Mississippi River Near Port Sulphur, Louisiana, Fall 1985*

	Port Sulphur Revetment					Port Sulphur Natural Bank	
Taxon	Shipek Grab	Hess	ACM Slabs	Core	Drift	Shipek Grab	Snags
Diptera							
Heleidae							
Palpomyia sp.		12					
Chironomidae							
Chironomidae pupae		198	8	20	2	170	79
Orthocladiinae							
Cricotopus sp.		871	215				968
Cricotopus intersectus		1,565	104				710
Nanocladius sp.						24	
Nanocladius distinctus			15			73	
Tanypodinae							
Ablabesmyia parajanta						24	
Chironominae							
Cryptochironomus sp.	24	47	9			340	
Dictrotendipes sp.		2,894	970	20			5,954
Dicrotendipes neomodestus		270		20			114
Dicrotendipes nervosus I		2,835		20	1		31
Dicrotendipes nervosus II		12					16
Goeldichironomus sp.		82	15				
Goeldichironomus pictus		224	100				6
Phaenopsectra sp.							3
Polypedilum halterale	24	24	30			461	53
Polypedilum illinoense							16
Rheotanytarsus sp.		12				24	16
Stenochironomus sp.							19
Copepoda	170	236	23		236	655	4
Cladocera							
Daphnia sp.	49				8		

(Continued)

* Densities are numbers per m^2, except for drift, which is numbers per 100 m^3.

(Sheet 1 of 3)

Table B6 (Continued)

Taxon	Port Sulphur Revetment: Shipek Grab	Hess	ACM Slabs	Core	Drift	Port Sulphur Natural Bank: Shipek Grab	Snags
Amphipoda							
Corophidae							
Corophium sp.				180		146	12
Gammaridae							
Crangonyx sp.			3	80			2
Gammarus sp.		12	5	80		170	
Talitridae							
Hyalella azteca						73	
Isopoda							
Asellidae							
Lirceus sp.		12	4	40			
Ascellus sp.						49	
Gastropoda							
Goniobasis sp.		12					
Pelecypoda	510					194	
Ephemeroptera							
Ephemeridae							
Pentagenia sp.		12			1	49	
Coelenterata							
Cordylophora	+		+			+	
Hydra					+	+	
Hirudinea				20			
Trichoptera							
Hydroptilidae							
Neotrichia sp.							2
Leptoceridae							
Nectopsyche sp.						97	
Decapoda							
Palaemonidae							
Macrobrachium ohione							2
Microturbellaria		12				73	
Nematoda	680					1,092	

(Continued)

\+ indicates taxa for which counts cannot be made (colonial forms).

(Sheet 2 of 3)

Table B6 (Concluded)

Taxon	Port Sulphur Revetment Shipek Grab	Port Sulphur Revetment Hess	Port Sulphur Revetment ACM Slabs	Port Sulphur Revetment Core	Port Sulphur Revetment Drift	Port Sulphur Natural Bank Shipek Grab	Port Sulphur Natural Bank Snags
Annelida							
Polychaeta							
Polydora sp.		12				73	
Oligochaeta							
Aeolosomatidae				1	1		
Tubificidae							
Aulodrilus pigueti	680						
Limnodrilus hoffmeisteri						49	
Limnodrilus maumeensis						340	
Limnodrilus udekemianus	24					24	
Stylaria fossularis							3
Tubificidae (nc)**		47	11	100		4,806	16
Tubificidae (c)	218					24	
Naididae							
Nais elinguis				20			
Nais pardalis		4,976	440	20	1		541
Nais variabilis							47
Pristina irdrensis	97					121	
Lumbriculidae				20		97	
Total/m^2	2,476	14,377	1,952	620	250	9,248	8,614

** (c) indicates immature tubificids posessing capilliform chaetae; (nc) indicates forms without capilliform chaetae.

(Sheet 3 of 3)

APPENDIX C: MACROINVERTEBRATE DATA FOR THE ACM SURFACE MODIFICATION EXPERIMENTS

Table C1

Taxa of Macroinvertebrates, and Estimated Densities per Square Metre Collected from Modified and Control ACM Experimental Blocks

Taxon	Marshall-Brown's Point Revetment			Port Sulphur Revetment			
	Grooves	Holes	Control	Grooves	Holes	Fish-Hab	Control
Diptera							
Chironomidae							
Chironominae							
Dicrotendipes neomodestus				407	183	156	349
Dictrotendipes nervosus I						13	
Micropsectra sp.				12			
Polypedilum convictum	111	15	15				
Polypedilum nr *scalaenum*				25		3	
Rheotanytarsus sp.	631	725	583				
Chironomus sp. 1						13	
Orthocladiinae							
Cricotopus intersectus Gr.				105	124	118	158
Cricotopus sylvestris Gr.				12			
Cricotopus tremulus Gr.						7	
Nanocladius distinctus	133	47	41	14		26	
Thienemanniella nr *fusca*	20	16					
Empididae	2						
Ephemeroptera							
Bactidae							
Baetis sp.	4						
Heptageniidae							
Stenacron sp.	2						
Stenonema sp.		4	7				
Stenonema integrum	2						
Coelentetrata							
Cordylophora	+	+	+			+	
Hydra				+	+	+	
Isopoda							
Asellidae							
Lirceus sp.				7	2	2	2
Pelecypoda					2		
Corbiculidae							
Corbicula fluminea	2						
Amphipoda							
Gammaridae							
Gammarus fasciatus		3		12	4	1	10
Corophidae							
Corophium lacustre	47	30	4	19	6		3
Trichoptera							
Trichoptera (mutilated)							2
Hydropsychidae	1,017	674	620				
Hydropsyche orris	2,866	687	804				
Potamyia flavens	114	50	33				

(Continued)

Table C1 (Concluded)

Taxon	Marshall-Brown's Point Revetment			Port Sulphur Revetment			
	Grooves	Holes	Control	Grooves	Holes	Fish-Hab	Control
Leptoceridae							
Nectopsyche sp.	2						
Ceraclea sp.		2					
Polycentropiidae	2						
Gastropoda							
Pleuroceridae							
Goniobasis sp.	2						
Physidae							
Physa hawnii						1	
Ancylidae		2					
Nematoda	13	24	4	47	25	6	4
Aeolosomatidae				12			
Coleoptera (larvae)	2	2					
Decapoda				1			
Bryozoa							
Entroprocta							
Urnatella gracilis	6	6	4				
Nemertea							
Prostoma rubrum	2	3		23	9	2	4
Annelida							
Echytraeidae				5			19
Naididae							
Dero trifida				73	16	4	
Nais pardalis			41	2,368	367	1,453	416
Nais variabilis				137	15	251	13
Pristina aequiseta						16	
Pristina digitata				73			
Pristina longiseta				12			
Pristina irdrensis				139		23	
Pristina sima				27		84	
Stephensoniana tandyi						4	
Tubificidae	2			1			
Branchiura sowerbyi				1			
Acarina	17	16	11				
Turbellaria							
Tricladida							
Dugesia tigrina	4	2	4	1		1	
Anisoptera							
Corduliidae							
Neurocordulia molesta	4						
Mean Density/Block	5,007	2,308	2,171	3,533	754	2,184	980
Location Totals	9,486			7,451			